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A Competitive Contrast Report of

Yaskawa E7

ABB ACH400

Cutler-Hammer HV9000

Danfoss VLT6000

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A COMPETITIVE CONTRAST REPORT OF
YASKAWA E7
ABB ACH400
CUTLER-HAMMER HV9000
DANFOSS VLT6000

Prepared For

Yaskawa Drives Sales Department

This document compares the features and performance of the Yaskawa inverter (drive) to a competitor's inverter, considered similar. Competitor information is obtained primarily from Technical Manuals. Secondary sources include brochures, website, and performance tests. Yaskawa assumes no responsibility for the accuracy of competitor data. This comparison should be used for reference only.

Prepared by: DSD Engineering
Yaskawa Electric America
Date: January 6, 2003

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I. Summary

This comparison should assist Yaskawa sales in understanding the strengths and weaknesses on the E7 drive product vs. the competition.

This comparison evaluates four AC drive products primarily targeted at commercial building automation/ HVAC fan and pump applications.
The drive products evaluated are:

- Yaskawa E7
- ABB ACH400
- Danfoss VLT6000
- Cutler-Hammer HV9000

The E7 drive is well placed to effectively compete in the targeted applications and markets.
The drives are evaluated in 15 different areas ranging from physical construction to troubleshooting and maintenance.
The E7 has different strengths when compared to each of the competing products.

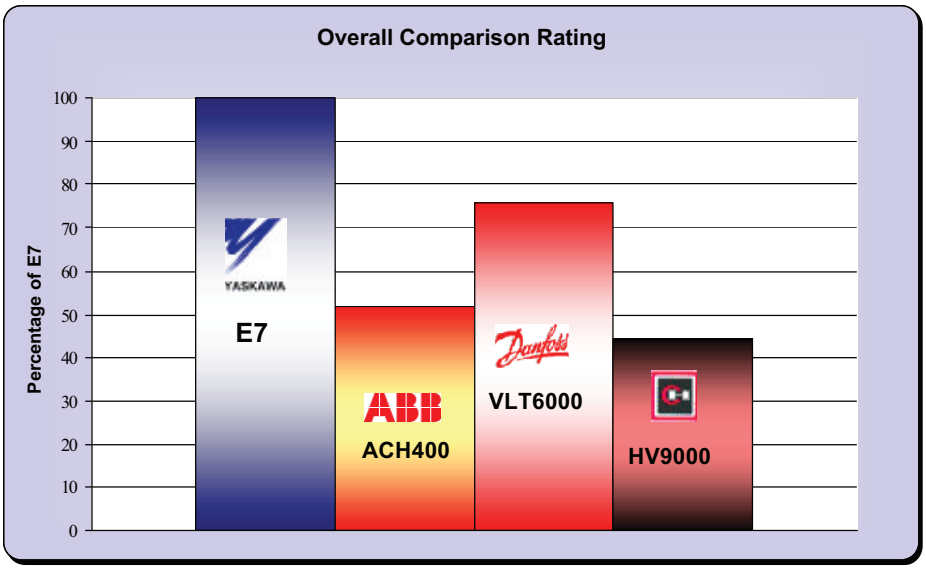
- When the E7 is compared to the ABB ACH400 the E7 is much stronger in the areas of wiring, keypad, I/O flexibility and communications.
- The E7 has a significant advantage over Cutler-Hammer HV9000 in areas such as, ease of maintenance, wiring , physical construction and programming.
- Finally, when the E7 is compared to the Danfoss VLT6000 the strongest competitor, physical construction and parts removal/installation are short comings of the Danfoss drive

The E7 is stronger than all the competition in several areas such as:

- Physical Construction
- Input/Output Interface
- Troubleshooting and Maintenance

Figure 1. below provides a summary of the E7 vs. the competition. The chart considers all features and provides an average result for all compared areas.

Figure 1.



II. Competitor Background Information[1]

A. Yaskawa

Since 1915 Yaskawa Electric Company has been manufacturing sophisticated electrical products. Yaskawa's sales were $2.3 billion in fiscal 2000. Yaskawa with its international operations offers Electrical system products for consumer, commercial, industrial, municipal, and utilities. The company divides its products into Industrial Electrical Control systems. Industrial Electric Components Mechatronics Systems, and Mechatronics Components products. Nearly 47 percent of it sales are from the Mechatronics Components group. This group offers motion and drive control products, including AC drives, AC/DC Servomotors motion controllers, servo systems, numeric controllers, and programmable controllers. Yaskawa pursues many alliances and partnerships to best succeed in the marketplace. Yaskawa has a 13.6% market share of low power AC drives in North America for the year 2000.

Yaskawa AC Drive Business

Yaskawa manufactures and assembles AC drives in facilities in Europe, Japan and the United States. Yaskawa opened a new North American headquarters in Waukegan, IL in 1999 with the goal to become the number one automation drives supplier in the US. The high volume smaller units are manufactured in Scotland and Japan. Mid-sized units are manufactured in the US, while Japan still manufactures the lower volume larger units. North America is the largest market for Yaskawa's manufactured products.
Yaskawa AC Drives are aimed at a variety of industries and applications. A few examples of these applications are elevators and air conditioners in the building automation industry. Other models are used in municipal water for control pumps and transportation for monorails. Yaskawa offers are variety of products to meet the demands of the industrial marketplace. For simple applications, Yaskawa offers small general-purpose; ultra compact variable speed drives, which are easy to operate. General-purpose drives are offered to meet the general needs of the industry. Yaskawa also offers highly functional, high-speed vector – controlled inverters. Other Yaskawa product lines are designed for energy savings, and low noise operation.

B. ABB

Founded in the late 1800's, ABB, with annual revenue of about $23 billion in 2000, is one of the largest industrial companies in the world. ABB serves manufacturing, process and consumer industries, utilities, and the oil and gas markets, with 160,000 employees in more than 100 countries. World headquarters is in Zurich. ABB has a 9.0% market share of low power AC drives in North America for the year 2000.

ABB AC Drive Business

ABB is the largest supplier of AC drives. ABB was an early supplier of AC drives to the pulp & paper industry. Today building automation, metals & mining, and pulp & paper are ABB's largest markets for AC drives applications such as, fans, HVAC, extrusion, material handling, metal processing, pumps and web handling.
ABB offers a complete product mix from micro to mega drives. A majority of the company's drives are furnished through direct sales and distributors. ABB generally supplies drives to end-users and some drives to OEM's and system integrators. The drives are supplied to end-users in either stand-alone or system configurations.
ABB's installed base is varied in the industry. In the industrial market, fixed torque applications are prevalent and in the commercial HVAC market, variable torque systems are more common.

[1] All Competitor Information obtained from: Low Power AC Drive North American Outlook-Market Analysis and Forecast Through 2005, ARC Advisory Group 2001.

Competitor Background Information[2] (continued)

C. Danfoss

Danfoss, with headquarters in Nordborg, Denmark, has annual sales of over $1.8 billion in 2000 with approximately 17,000 employees. There are sales representatives, sales offices, and service centers in 100 countries. The company is divided into three business segments: Heating & Water, Refrigeration and Air Conditioning, and Motion Controls. Danfoss has a 4.0% market share of low power AC drives in North America for the year 2000.

Danfoss AC Drive Business

Danfoss Drives manufactures over 100,000 drives a year with its 1,800 employees and three manufacturing facilities located in Graasten, Denmark; Rockford, Illinois; and Milwaukee, Wisconsin. In Canada and the US, there are over 100 sales and service centers. In 1995 Graham was acquired and became a division of Danfoss.

1) Danfoss Electronic Drives

Danfoss Electronic Drives, a division of Danfoss A/S, markets drives for general application in industry such as HVAC, Water, Chemical, Food & beverage, Material Handling and water & waste. Danfoss manufacturers drives from the compact drive to the high end. Several mid-performance inverters are available in compact sizes to high-end sizes to be used in either constant or variable torque applications.

2) Graham

Graham is a division of Danfoss Inc., which specializes in marketing AC drives specifically designed for the HVAC industries. PWM units are available from micro to midrange sizes. Small vector controlled PWM drives ar part of the product line that may be applied to constant or variable torque applications. PWM's are offered, which produce a six-step output that lowers motor stress.

D. Eaton Cutler-Hammer

Eaton Corporation is a global $8 billion diversified industrial manufacturer of fluid power systems; electric power quality, distribution and control; automotive engine air management and fuel economy; and intelligent truck systems for fuel economy and safety. Eaton's 55,000 employees work in 29 countries on six continents. Eaton's Industrial and Commercial Controls business segment manufacturers contactors, starters, drives, and other motor control products. Global markets are served by direct sales through the company or by indirect sales through distributors and manufacturer representatives. Eaton Cutler-Hammer has a 2.2% market share of low power AC drives in North America for the year 2000..

Eaton Cutler-Hammer AC Drive Business

Cutler-Hammer is part of Eaton's Industrial and Controls segment. The company supplies products for power distribution equipment, electrical control, and advanced industrial automation. Included in its product offering are Cutler-Hammer's AC drives, from micros to midrange sizes. Cutler-Hammer has greatly reduced operating costs by standardizing the AC drive product line on a single model. Cutler-Hammer employs the same drive technology over the entire range. The commonality of components can have significant saving for the end user in training and spares.

This multi-purpose PWM drive provides Volt/Hz, sensorless vector and closed loop flux vector modes of operation. It may be applied to constant torque or variable torque applications. The drive is preprogrammed with selectable control for various applications such as pumps, fans, mixers, ex- truders, cranes, packaging, and material handling.

[2] All Competitor Information obtained from: Low Power AC Drive North American Outlook-Market Analysis and Forecast Through 2005, ARC Advisory Group 2001.

III. Objective

The evaluation is undertaken to provide a key selling tool to assist in competing with other Building Automation AC drive products. Yaskawa needed a detailed comparison of features and benefits vs. the targeted competition. The goal is to expose the weakness of the competition and to highlight the strengths of the Yaskawa E7.

IV. Methodology and Approach

Yaskawa Electric America performed a side-by-side comparison of three AC drive products targeted at the Building Automation and HVAC market. Comparable features are grouped into categories such as "Physical Design or Serial Communications" . The categories contain features or functions that are listed and rated under each category.

A category summary is included in each section to assist the reader in understanding the importance of each category to the customer or within the HVAC market. A table containing feature descriptions is provided along with a percentage bar graph of the category rating. In addition, a textual summary contrasting the E7 and highlighting any competitive advantage of the E7.

Table Description

Features that can be logically compared are placed in tables.
A feature or function is scored based on how it compares to the E7. Each feature evaluated rated or scored as follows:

Rating Values

- **0=Yaskawa Advantage, not as good as E7**
- **4=Competition Advantage, better than E7**
- **2= equal to Yaskawa E7**
- **NR = Not Rated**

The Rating System

The rating system allow for a 0%-200% score for each category. The E7 always gets a 100% as a benchmark. This is because the E7 is the standard for which all competing products are compared.

- The rating values are chosen such that if a competing product scores **"4" better than E7"** in all features in a category, then that product will receive a 200% overall category rating on the associated bar graph.
- If a competing product scores "0 Not as good as E7" in all features in a category then that product will receive a 0% overall category rating on the associated bar graph.
- Should a competing product score "2 Equal to Yaskawa E7" in all features in a category then that product will receive a 100% rating equal to the E7 on the associated bar graph.

Combined Total Overall Rating

An overall rating is determined by averaging all of the category score percentages to determine if the competing product is better than, equal to, or equivalent to the E7 and by what percentage.

V. Fan and Pump Application Primer

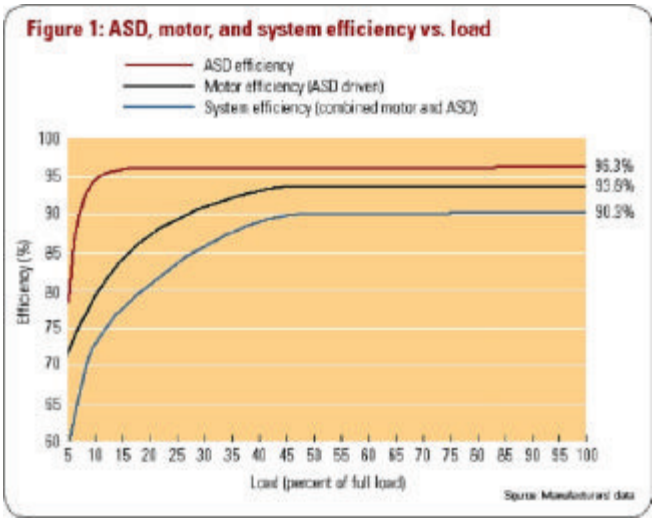
Since variable speed drives were invented some 20 years ago, energy efficiency has been one of their main selling points.

VFD's provide an opportunity to reduce energy costs by eliminating unnecessary losses in the application. In a variable volume fan application where inlet dampers or output vanes are used to control the airflow, substantial energy costs can be obtained with the application of ac drives. By controlling the speed of the fan directly, flow can be controlled and pressure losses across the fan blades can be reduced. In many applications, as much a 50% reduction in energy costs have been obtained by using ac drives to control the air flow.

A classic **energy efficiency application** is the use of drives to control the speed of the motors that turn blowers and fans in air handing units in commercial buildings. Motor speed control alleviates the need for dampers in ductwork, and by slowing fan speed during lower demand cycles, the reduction in energy used during those periods will eventually offset the cost of the equipment. **Drives** are often integrated into building control, electrical and mechanical systems. Though their immediate and primary impact is a reduction in energy costs, they must operate without fail. For this reason, redundant systems such a bypass and mechanical flow control are often also installed. Other energy efficiency applications include pumps, chillers, and in some cases elevators.

ASDs provide dramatic energy savings by optimizing the motor/load system--not by improving the actual efficiency of the motor in isolation, as an energy efficient motor retrofit would (**Figure 1**). Average loading as high as 90 percent can justify ASD retrofit for high-duty, high-utility-rate applications. In addition, the improved power factor provided by an ASD (especially pulse-width modulation (PWM) ASDs) can produce additional savings due to reduced I^2R losses in the cables supplying power to the drive and motor.

A survey in the United States has showed that some 40 per cent of the energy used in non-residential properties is used in HVAC applications, such as ventilation, space heating and space cooling. Using variable speed drives ensures this energy is used efficiently.

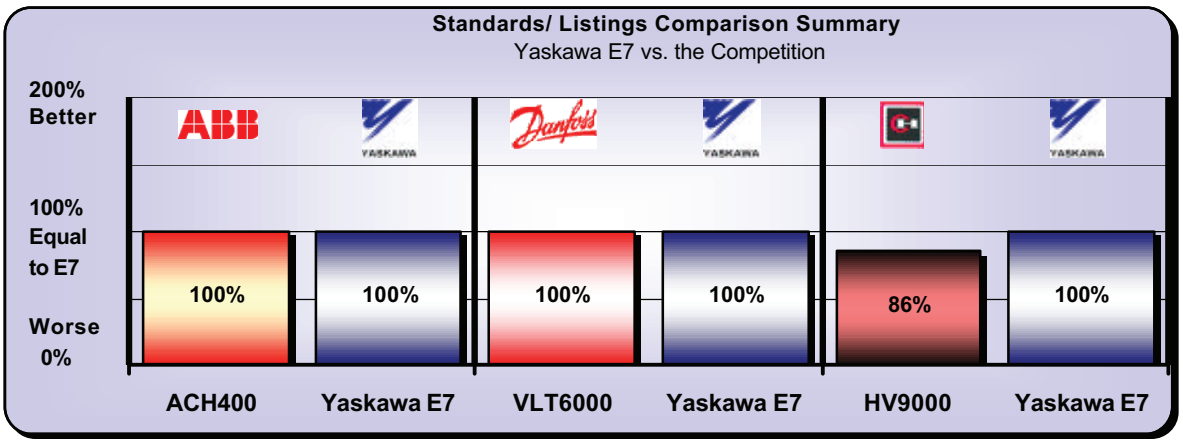


VI. Evaluation Section

This section shows evaluated features broken into groups. Each feature is rated in a table and a percentage of E7 score is shown at the bottom of each table. The percentages are also graphed for easy interpretation. In addition, A short comparison paragraph highlights the advantages of the E7 over the competition.

A. Standards

Standards and listings provide practical information concerning ratings, construction, test and manufacture of industrial equipment. Standards are used by the industry to provide guidelines for the manufacture and proper application of products and equipment. Standards can be application specific or very broad. It is important to understand that a manufacturer may claim adherence to a standard without specifying the "Category or Environment" within the standard. Marketing literature typically does not explain such detail. The ability of a product to comply with standards that are specified by potential users is an indication that the product is well suited to its market. Standards that are typically referenced in the Building Automation System (BAS) marketplace are chosen as a basis for this comparison.



Standards Comparison

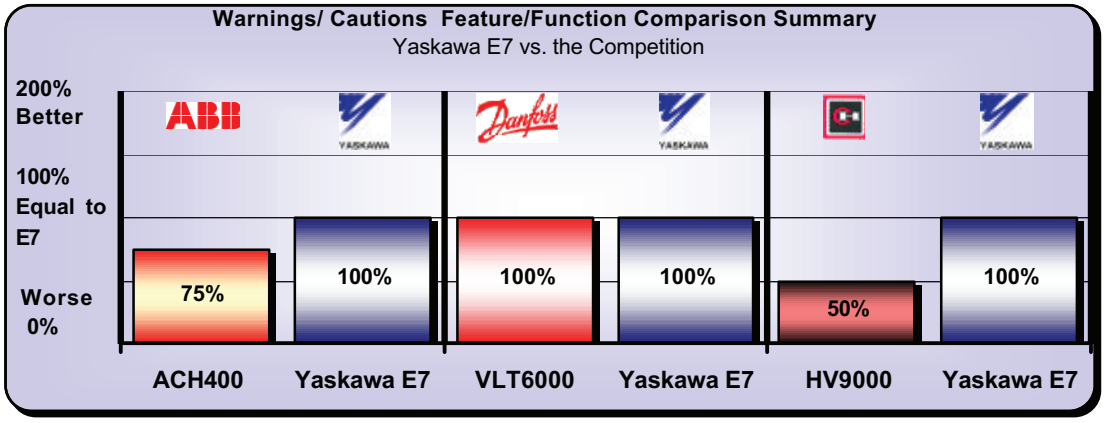
The E7 is compliant with most popular standards and is on equal to the competition in the evaluated areas. Evaluation in this area is limited, as some unique standards require evaluation on a case-by-case basis. In addition, certain standards may be popular in other global markets, which are not the focus of this report.

No.	Standards/ Listings Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	UL 508C	2	Yes	2	Yes	2	Yes	2	Yes
2.	CSA 22.2 No. 14-95 (Industrial Control Equipment)or cUL	2	cUL	2	cUL	2	cUL	2	cUL
3.	UL 1995 Plenum	2	Yes	2	Yes	2	Some models require NEMA 12	0	Not published
4.	CE Mark	2	Yes	2	Yes	2	Yes	2	Requires EMC filter
5.	Standard EN50178 of **(LVD)**Low Voltage Directive 73/23/EEC	2	Yes	2	Yes	2	Yes	2	Yes
6.	Standard EN61800-3 of **EMC** Directive 89/336/EEC amended 93/68/EEC	2	w/ external filter	2	w/ external filter	2		2	Open chassis requires input external RFI filter.
7.	IEEE 519: Harmonic Control in Electrical Power Systems	2	w/12 pulse	2	w/optional filter/reactor	2	Built-in DC link w/optional filter/reactor	2	Integral 3% AC three phase reactor supplied.> 2HP Optional separate 12 pulse bridge >100HP
	TOTAL SECTION SCORE	**14**	= 100%	**100%**	of E7	**100%**	of E7	**86%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

B. Warnings and Cautions

A properly labeled product and documentation can help prevent damage to equipment and danger to personnel. However, warnings and cautions that are unique and/or excessive may be an indication that the product design is not well suited to its application. Manufacturers should attempt to fully document product warnings and cautions. The product should be of robust designed to minimize unique warnings or cautions. This comparison rates how well warnings and cautions are documented and penalizes products for unique cautions that may limit user or application flexibility.



No.	Warnings/Cautions	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Number of warnings or dangers.	2	18	2	18	4	36	0	10
2.	Number of cautions.	2	30	0	20	0	29	0	13
3.	Number of warnings or cautions not labeled or improperly labeled as warnings or cautions.	2	30	4	11	4	10	4	1
4.	Number of unique warnings/cautions that may limit user flexibility.	2	0	0	3	0	11	0	5
	TOTAL SECTION SCORE	**8**	= 100%	**75%**	of E7	**100%**	of E7	**50%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

Note: These definitions are used to determine a "Warning or a Caution"

Warning-Danger or injury to personnel

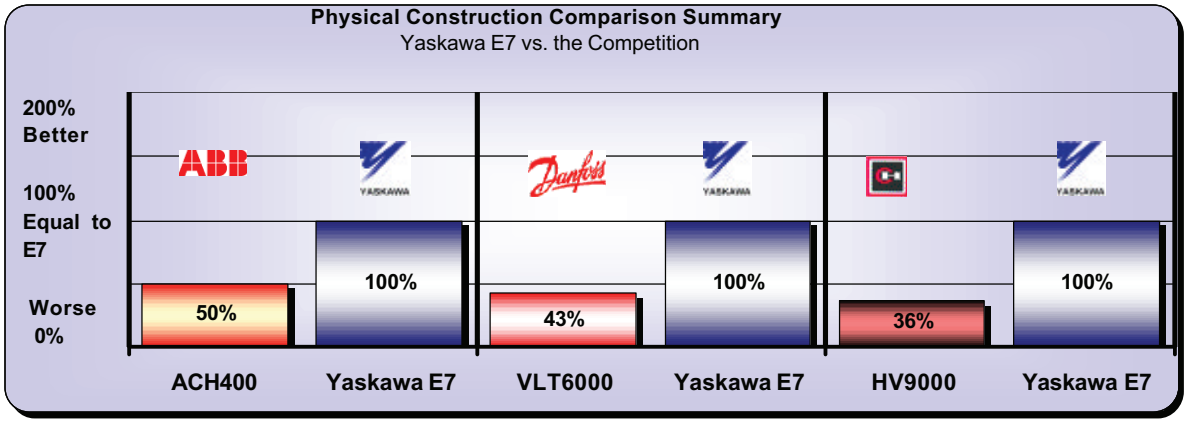
Caution: May cause damage to equipment.

Note for 1. or 2.--All notes or text that fit the warning or caution definition above are counted as warning or a caution even if it is not labeled as such.

Note for 2. – Warning or cautions mabe be counted multiple times. If a warning or caution is considered as "a unique a unique warning or caution" in **No. 3** above., it is also considered in the total number of warnings or caution in No. 1 or 2 above.

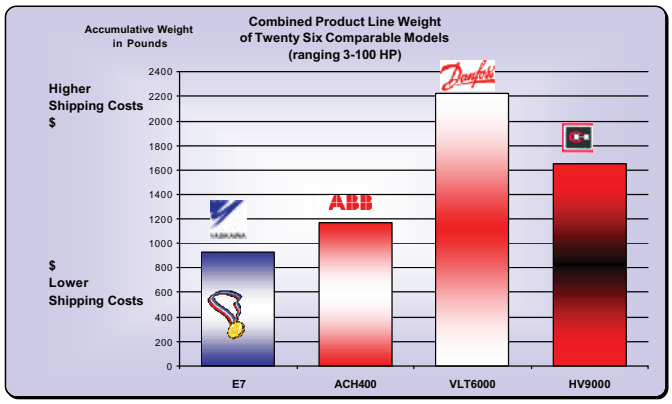
C. Physical Construction

Good physical design can be measured by several important factors. Compact design can help save valuable enclosure or floor space. Installation and repair time can be minimized by well-designed enclosure features. A variety of available enclosure types can help ensure the drive can tolerate its environment. Conveniently placed exterior labels, markings and other indicators can reduce time and effort required to identify the drive or troubleshoot systems faults. This comparison focuses on rating the products exterior design physical construction features. Electrical component construction is beyond the scope of this comparison.



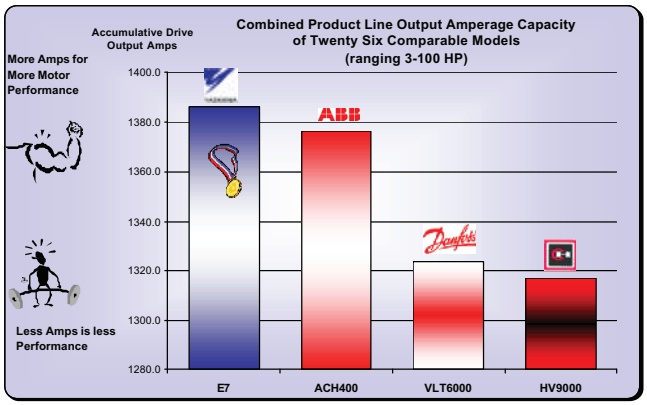
Product Weight Comparison

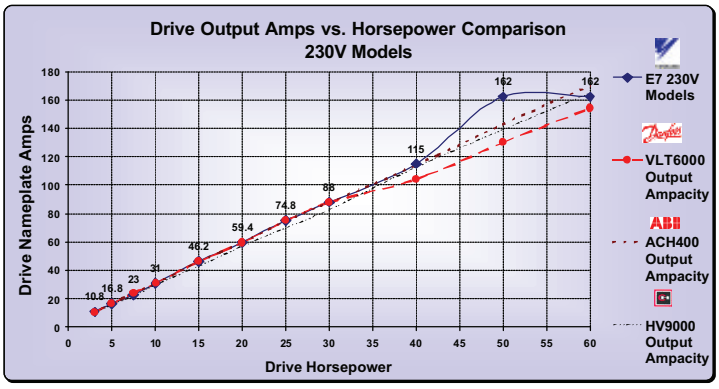
The E7 product weighs 50% less than the Danfoss VLT6000. The E7 also compares favorably to the HV9000 and the ACH400 in this area. Yaskawa fits great performance in a light package. This results in lower shipping costs and comparatively easier installation.

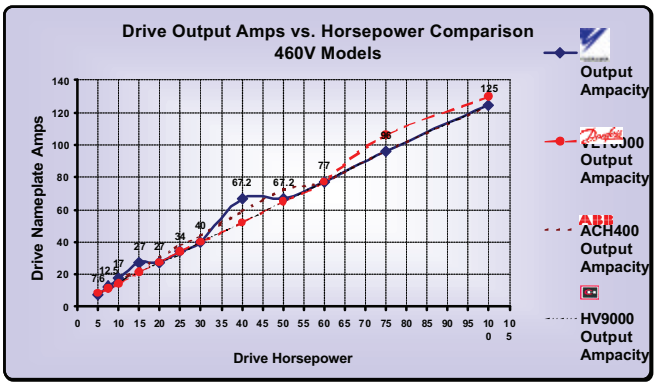


Output Ampacity Comparison

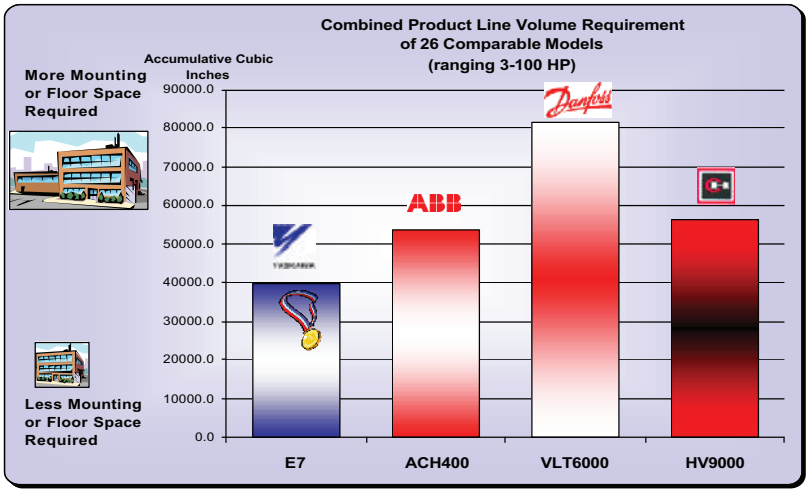
The E7 product line provides more output amps overall than the competition. The E7 provides higher motor performance by delivering more amps to the load . A detailed chart indicates the E7 is especially powerful in the 230 volt class.

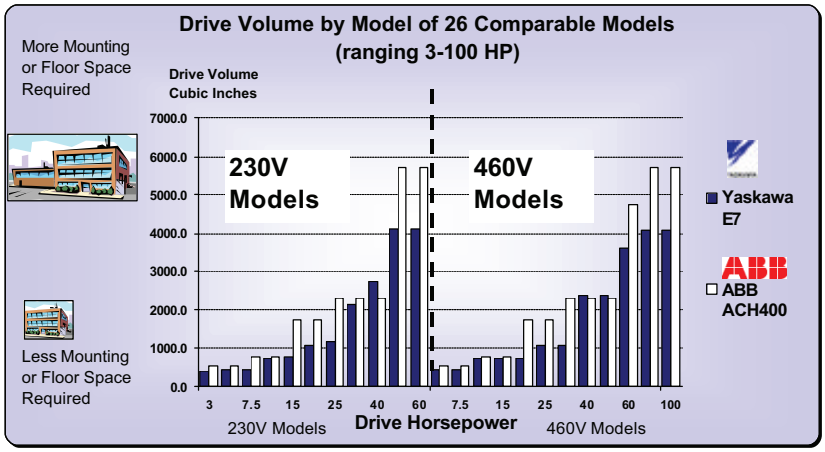


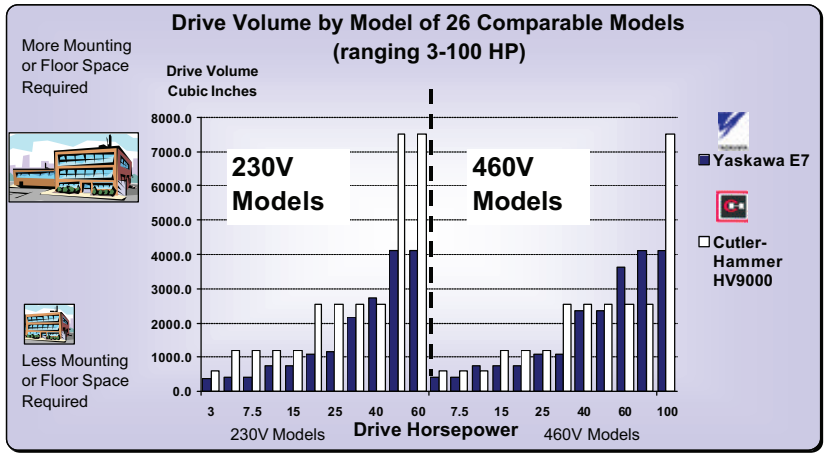


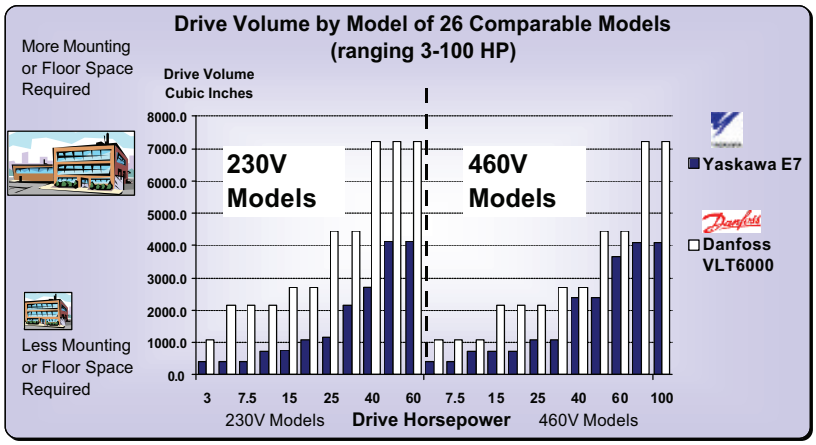


Physical Construction Comparison (continued)









Volume Requirement

The E7 beats the competition by providing the most compact drive size. Minimizing the space required by the drive reduces enclosure space cost as well as the cost for providing floor and wall space.

The most significant volume savings is obtained when the E7 is compared against the Danfoss VLT6000. The E7 drive line up requires 50% less volume than the Danfoss drive.

A model by model comparison shows that the Cutler Hammer HV9000 and the ABB ACH400 are at least 25% larger overall than the E7.

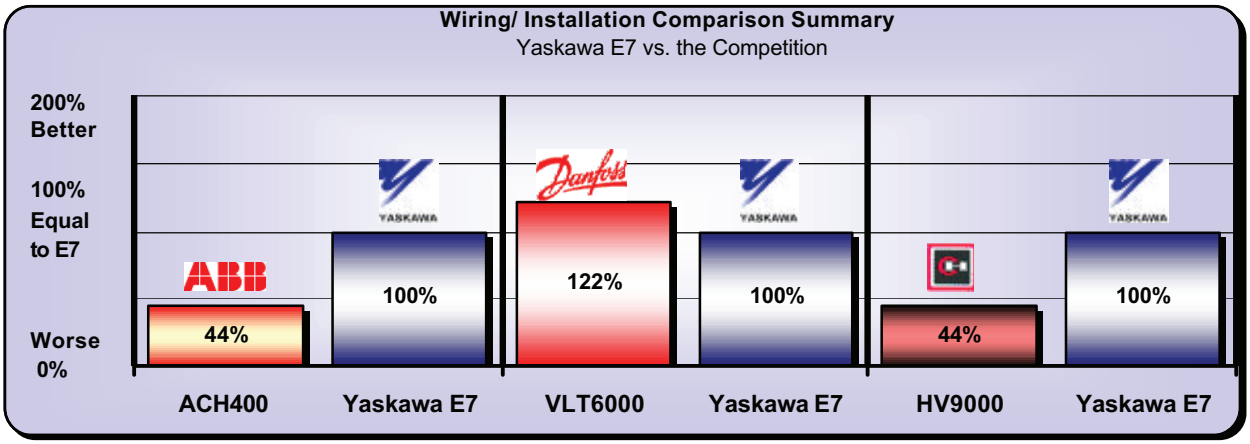
Physical Construction Comparison (continued)

No.	Physical Construction Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Total size by volume (cu. in) occupied by 26 different drives in 3-100HP line-up. NEMA 1 stand alone.	2	39847.63029	0	53771.25891	0	81776.59277	0	56188.7183
2.	Total combined weight of 26 different drives in 3-100HP line-up. (lbs)	2	934.4	0	1167.6	0	2226	0	1653.5
3.	Namplate Labeling.	2	Model: , Spec: , Input: V-Hz-A, Output: V-Hz-A, Order#: , Serial#: , Mass: , ULfile#: , Encl type: ,	0	Nameplate does not spell out Input/Output Example: U1-U2-I1n-I1nhd-I2n-I2nhd-f1-f2 are used-this is difficult to read. (Mass, UL file# and Enclosure Type not listed.)	0	Mass not listed , UL file# is on separate label	0	Mass not listed, UL file # not listed
4.	Other Markings/Labels.	2	Risk of Shock warning in two languages-front cover, Pass inspection stamp on heatsink.	2	Shock warning graphic	2	Service label with phone # , Shock Risk on bottom	0	Risk of Shock label on side of unit not visible from front.
5.	Listing/certification labels on enclosure	2	cUL, UL, CE	2	cUL, UL, CE on nameplate	2	cUL, UL, CE	2	cUL, UL, CE
6.	NEMA 1 convertible to chassis style.	2	Yes	0	No	2	Yes	0	No
7.	Replaceable exterior components.	2	Cover, sides, Fan No tools required	0	Cover , sides, fan w/tools	0	Yes, Top bottom, sides, fan w/tools	0	Sheet Metal is U formed sides cannot be easily replaced, fan w/tools
8.	Exterior components labeled w/ part number.	2	DigOP, FrontCover, Sides, fan bracket	2	DigOP, FrontCover, Sides	0	DigOp	0	DigOp
9.	Tools required to remove front cover.	2	#2 Phillips or flat	2	Flat screwdriver	2	Flat screwdriver	2	Flat screwdriver
10.	Standard NEMA 1 Range	2	NEMA1/IP21 wall mount to 500 HP 480V and to 150HP 240V,	0	NEMA 1/IP21 wall mount to 150HP 480V and to 100HP 240V,	0	NEMA 1/IP21 wall mount to 300HP 480V and to 60HP 240V,	0	NEMA 1/IP21 wall mount to 400HP 480V and to 100HP 240V,
11.	Standard NEMA 12 Range	2	Optional	4	NEMA 12/IP54 wall mount to 60HP 230V and to 100HP 480V,	4	NEMA 12/IP54 wall mount to 300HP 480V and to 60HP 240V,	4	NEMA 12/IP54 wall mount to 400HP 480V and to 100HP 240V,
12.	Open Chassis Available	2	All	2	Yes	0	No	2	Open Chassis IP00 to 150HP 230V and to 1000HP 480V
13.	Floor Mount Required	2	No-(Endcaps only)	0	NEMA 1/IP21 floor mount required 150-400HP- 480V and n/a 240V, NEMA 12/IP54 floor mount required 75-100HP 230V and 125-400HP-480V.	0	NEMA 1/IP21 floor mount required 350-600HP- 480V, n/a 240V, NEMA 12/IP54 floor mount required 350-600HP-480V, n/a 240V,	0	Floor Mount is optional kit
15.	Unique Enclosure Features	2	Removable fan-no tools lower HP models, Plower Half cover removal protects control PCB when wiring.	0		0		0	
	TOTAL SECTION SCORE	**28**	=100%	**50%**	of E7	**43%**	of E7	**36%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

D. Wiring

A drive that is easily wired can reduce both ownership and installation costs. Simple wiring and piping connections and components that can be replaced without rewiring results in a product that is economical to install and maintain. Cost savings can be further increased by a product that does not require expensive or highly skilled personnel to maintain or service.
This comparison evaluates features related to the wiring installation of the drive.



Wiring Comparison

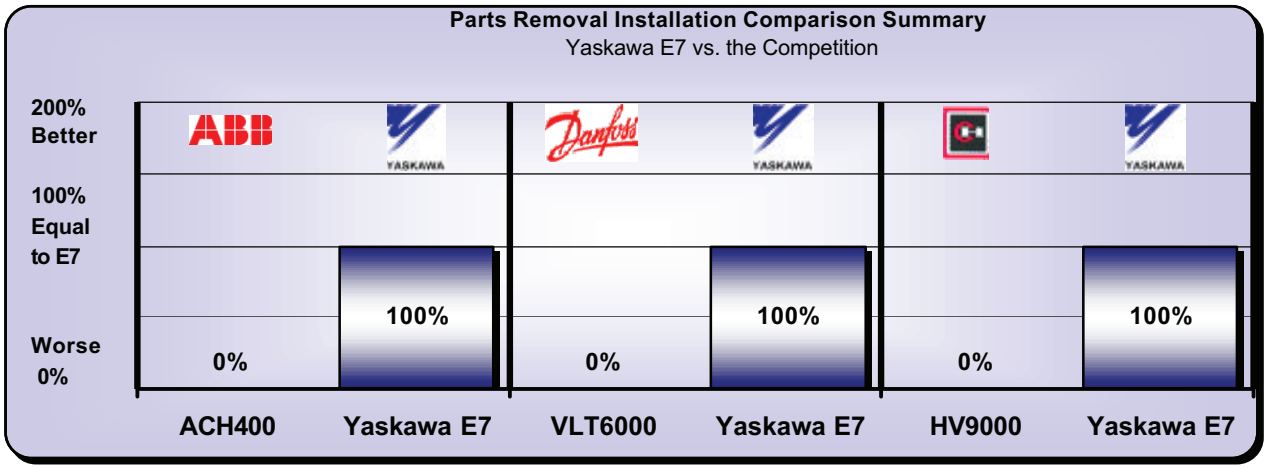
The competition was evaluated side-by-side with the E7. The sample drives used were 460V 5HP. The drives were mounted and wired to both control and power circuitry. The E7 is much easier to wire than Cutler-Hammer and ABB. The Cutler-Hammer HV9000 was especially difficult to connect. (see detailed photos). The ACH400 from ABB exhibited challenges in the control wiring. The Danfoss VLT6000 and E7 were equally convenient to wire and install. (see detailed photos and comments in the following pages).
The E7 provides simple, easy wiring and installation when compared to the competition. Wiring/ Installation features of the ABB and Cutler-Hammer drives rate poorly in comparison.

No.	Wiring/Installation Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Detachable conduit entry plate.	2	Yes	2	Yes	2	Knockouts	0	No
2.	Detachable control terminal blocks.	2	Yes	2	No	4	Yes PowerBlocks also	2	Yes
3.	Power Terminal labeling.	2	Clearly Labeled	0	Bottom of block , not easily seen	2	Clearly Labeled	2	Clearly Labeled
4.	Control terminal labeling.	2	Clear on cover	0	Silk screened on PCB but gets blocked when wired.	2	Clear on removable cover	0	Not clear terminals can be mixed up and improperly plugged easily.
5.	PCB component exposure during wiring.	2	Protected	2	Protected	2	Protected	0	60% exposed
6.	Ease of I/O access	2	TB is removable, plenty of dressing room	0	Difficult to close cover w/o pinching cable	2	TB is removable, plenty of dressing room. Block is at 45 degree angle to user+	0	Control wires are at 90 degrees to front metal cover with only 3/8 inch bending radius.
7.	Keypad removal required to wire?	2	No	0	Yes	2	No	2	No
8.	Terminal size and orientation.	2	I/O 3.5 mm spacing	2	I/O 3.5 mm spacing	2	I/O 3.5 mm spacing	2	I/O 3.5 mm spacing
9.	Wiring clearances	2	Minimum bending required. Bottom centry always good w/ removable conduit entry.	0	I/O clearance is not good w/ < 1 inch to side cover and 90 degree bend required.	4	Ample wiring room. Comfortable to wire.	0	Both control and power wiring have tight clearances and bending radius.
	TOTAL SECTION SCORE	**18**	= 100%	**44%**	of E7	**122%**	of E7	**44%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

E. Parts Removal Installation

As equipment ages, routine maintenance and parts replacement may be required. Parts replacement and the availability of service procedures should be easy to keep maintenance costs to a minimum. A spares program is often in place with HVAC systems, parts commonality between drive product will help keep the required inventory to a minimum. The comparison rates the competition against the E7 in parts removal and installation as well as access to parts and information.



F. Parts Removal Installation Comparison

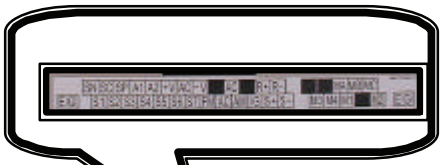
The E7 is the easiest drive to replace the main PCB. The ACH400 and VLT6000 presented a greater challenge to replace the main PCB. The Cutler-Hammer HV9000 has the most difficult PCB replacement with difficult to remove cable harnesses and tight finger clearances. (see detailed photo's on following pages).

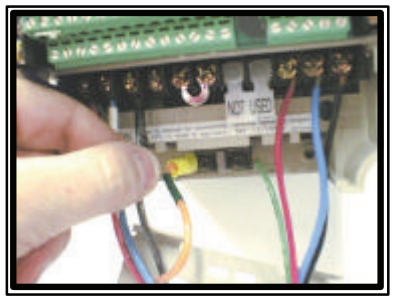
No.	Parts Removal Installation Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Spares recommendations/ Determining the part number	2	Excellent-complete primary spare parts list in user manual	0	No spares listed in manual only optional components	0	No spares listed in manual	0	No spares listed in manual only optional components
2.	Fan replacement	2	Excellent- Cassette removable fan w/o tools on smaller models.	0	Tools required	0	Enlosure disassembly required	0	Sheetmetal removal/ enclosure disassembly required
3.	I/O logic/control PCB replacement	2	Very simple-see detail	0	Difficult- see detail	0	Difficult-see detail	0	Extremely difficult - see detail
	TOTAL SECTION SCORE	**6**	**= 100%**	**0%**	of E7	**0%**	of E7	**0%**	of E7

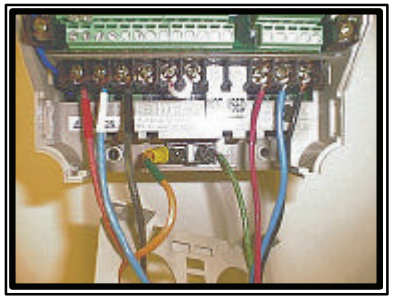
Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

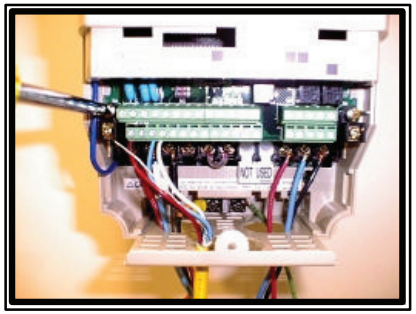
YASKAWA

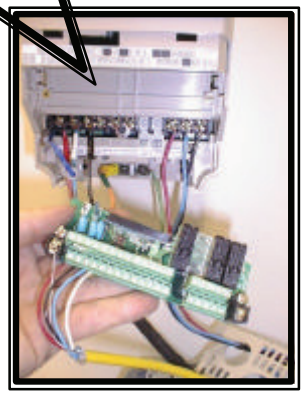
E7 Wiring – Comments: Wiring the E7 is easy and straightforward. Only two standard tools are required for wiring connections on this model. The unique split cover protects the control board and keeps the digital operator in place during wire termination. The easily removed pre-punched bottom conduit plate allows free hand movement. The I/O block is removed by loosening two captive screws and is easy to wire while holding in the hand. There were no unusual techniques or tools required in making wire terminations.

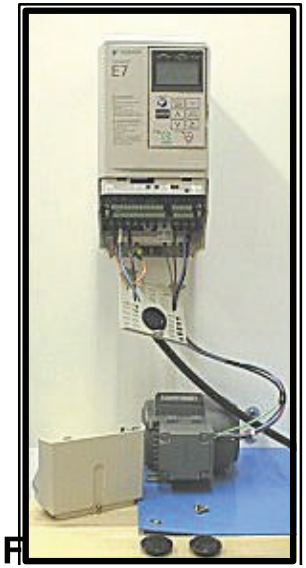






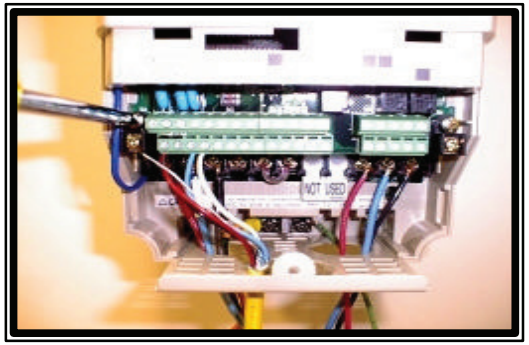


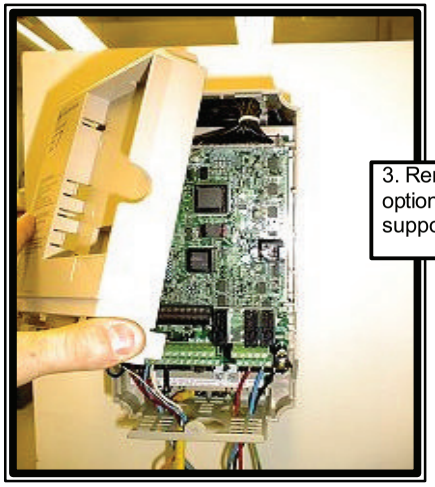


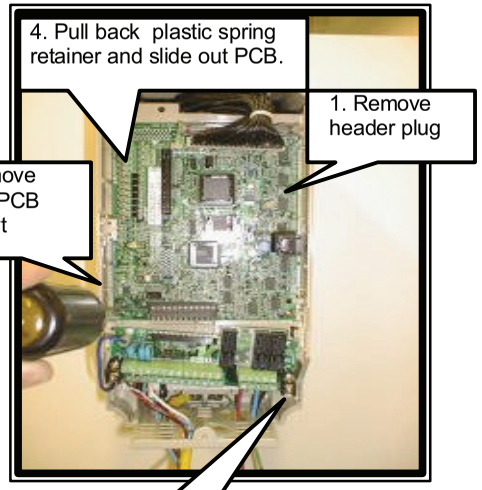


YASKAWA

E7 PCB Replacement – Comments: E7 main PCB replacement is performed with a single Phillips screw driver and without removing wire terminations. The top cover can be removed with one hand. Loosen and disconnect the pluggable I/O block, two retaining screws, a single header plug and pop out the board. Installation is the opposite and is just as simple. Notice that no high voltage connections or bus bars are dangerously exposed during removal.






4. Pull back plastic spring retainer and slide out PCB.
1. Remove header plug
3. Remove option PCB support
2. Remove left and right phillips screws

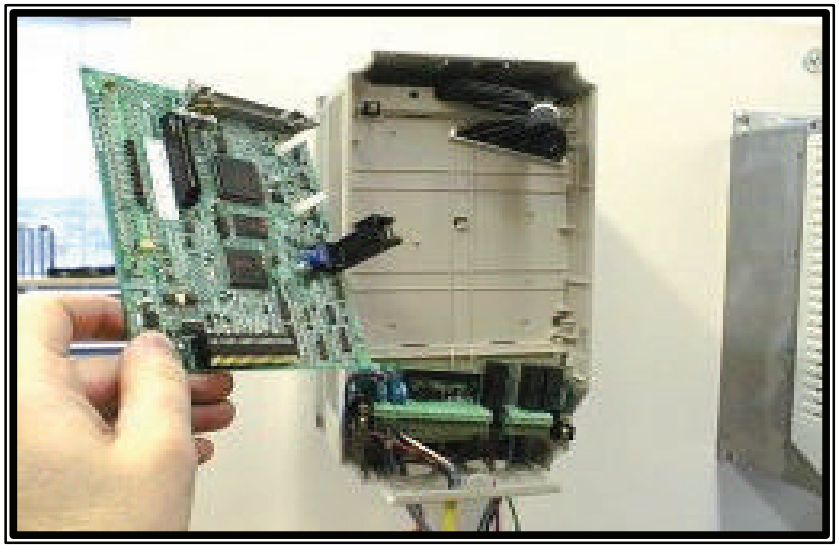


ABB ACH400 Wiring – Comments: Wiring the ABB ACH400 is more difficult than the E7. The front cover and keypad must be removed. Power wiring seemed straightforward, however it would be very difficult to route 27 control wires in the narrow path provided. A single 4-conductor shielded cable seemed to fill the channel. In addition, control wiring terminations are at a right angle to the entry point providing little bending radius and potentially stressing the wires. Wires are easily pinched and require careful dressing when replacing the front cover. Wiring terminations required three tools and took longer than the E7 due to control wiring

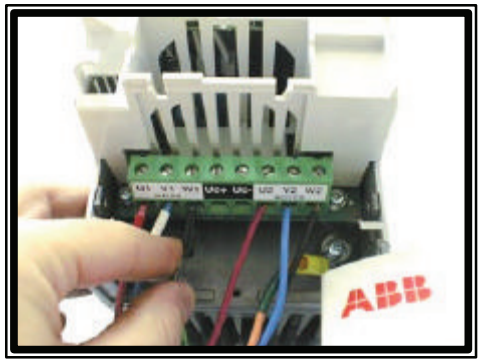
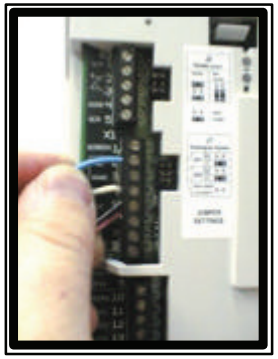
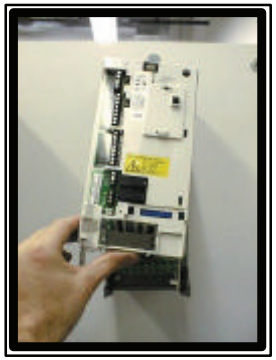
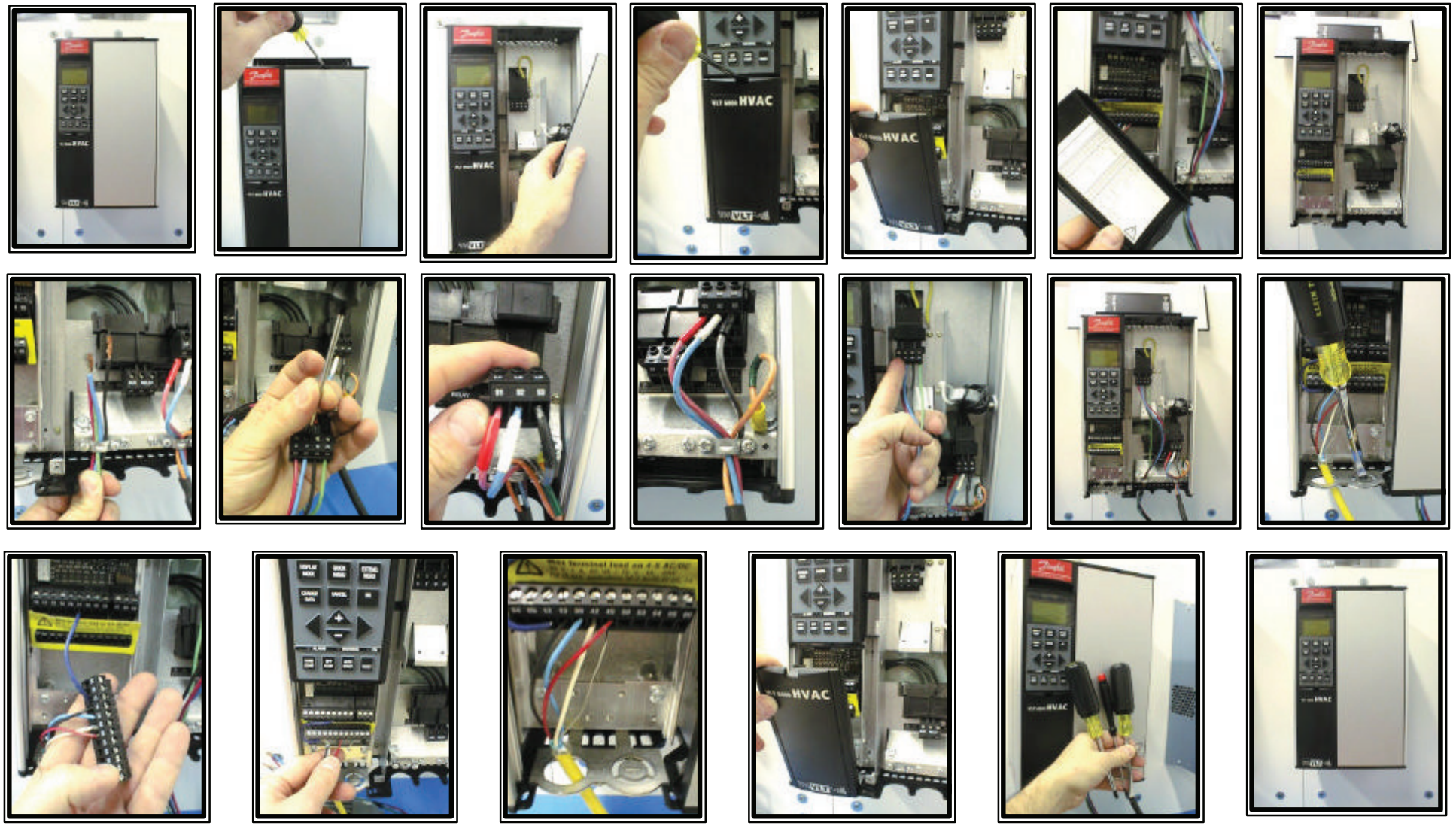


ABB ACH400 PCB Replacement – Comments: Replacing the ACH400 PCB is more difficult and time consuming, and requires more steps than the E7. The process required removal of all control wiring points, which may lead to wiring errors on reinstallation. Some guesswork is involved in understanding cover removal. Ultimately two tabs must be pried apart simultaneously before the cover can be removed. The PCB is held captive inside the front cover, which then hangs stressing two ribbon cables. It is easy to be intimidated by exposed high voltage circuitry when reaching to remove the ribbon cables. Two plastic retainers must be pried aside simultaneously to free the PCB. Three separate tools are required as well as rewiring of the control terminals.

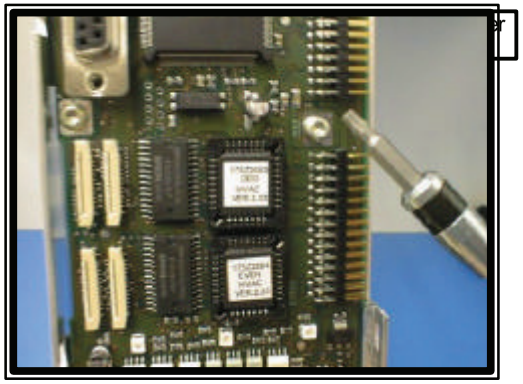


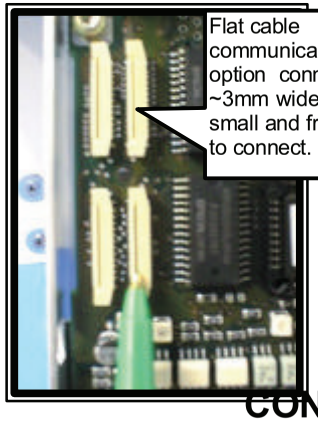


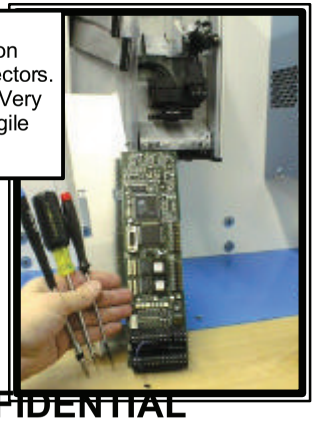
Danfoss VLT6000 Wiring – Comments: Wiring the VLT6000 did not pose any significant challenges. The plastic bottom conduit plate seems flimsy unless a metal plate is provided. The drive requires three tools to wire instead of two for the E7. One large flat screwdriver is used to remove the metal conduit knockout for the control wiring. The control wiring knockouts become a loose part and may get lost in the drive unless immediately discarded. The pluggable power connectors have the clamping point ¼ inch deep inside the connector. This makes it difficult to inspect for pinched wire insulation and proper electrical connection. In addition, the VLT6000 requires more effort to wall mount because it is the heaviest of the drives compared



Danfoss VLT6000 PCB Replacement – Comments: Replacing the control PCB on the VLT6000 was more difficult than the E7, with lack of instructions and special tools required. The VLT6000 manual does not describe PCB removal. A separate serial communications manual explained removal as a part of option PCB mounting. However, communication manuals are not shipped unless the options are installed. PCB replacement required a T9 Torx driver and two other screwdrivers (a total of three tools). The Torx driver is a specialty tool. PCB removal required loosening five screws and two ribbon connectors. In addition, if the gate drive PCB is replaced , chassis sheet metal will need to be removed.



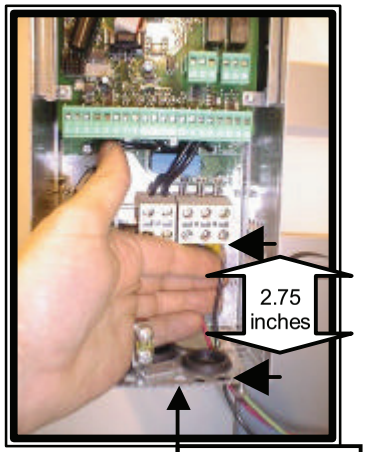




Cutler-Hammer HV9000 Wiring – Comments: Wiring the VLT6000 was the most challenging of all the drives. The HV9000 had tight clearances, sharp wire bending radius and four tools required. The control terminals are without keys can be easily plugged into the wrong position with four identical blocks. As short stubby screwdriver added to the tool set as removing the cover required access to the bottom of the drive. The HV9000 would be considered difficult to wire inside an enclosure when compared to the easy access of the E7.

Tallest drive with least bottom wiring clearance.

The HV9000 is the only drive where bottom access is required to remove the cover.

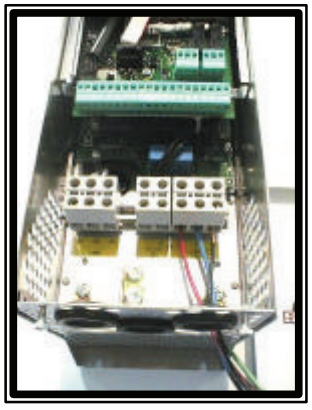


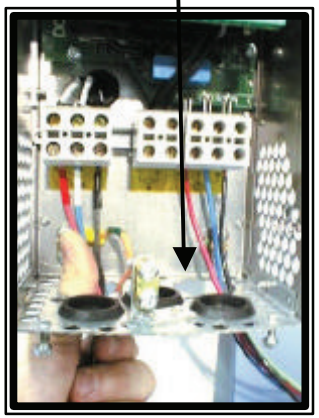
Non-removable conduit plate makes for tight fit.

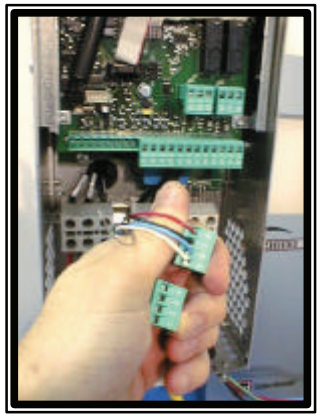
Non-removable conduit plate makes for tight fit.

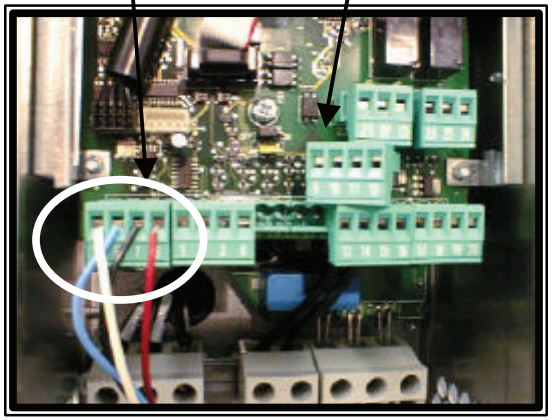
Sharp bending radius with wires at 90 degrees to cover. Only 3/8 inch spacing to front cover when installed.

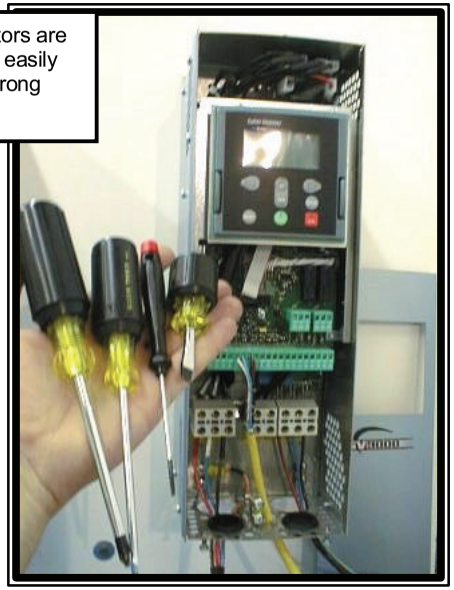
Pluggable connectors are not keyed and are easily plugged into the wrong position.



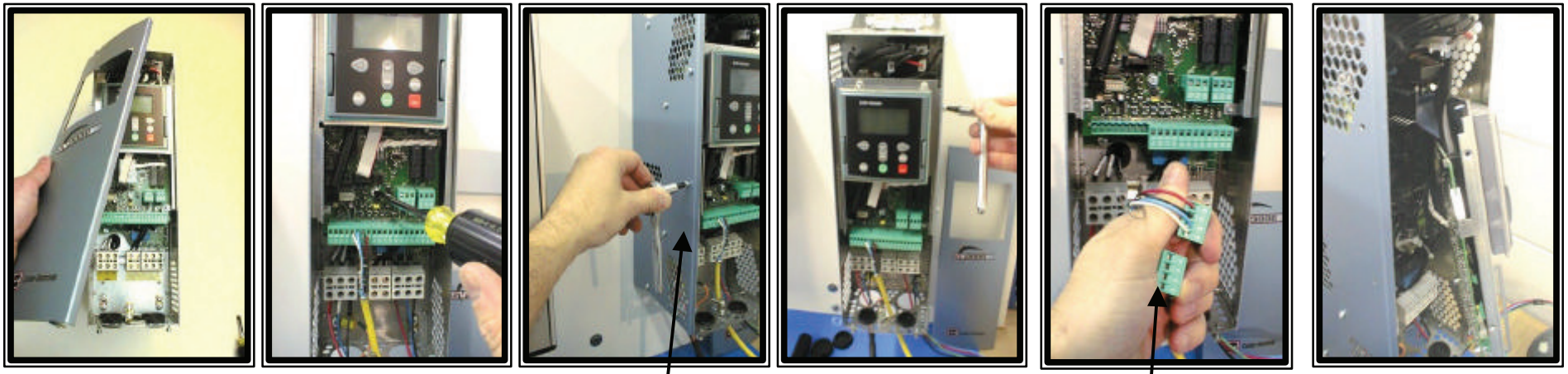


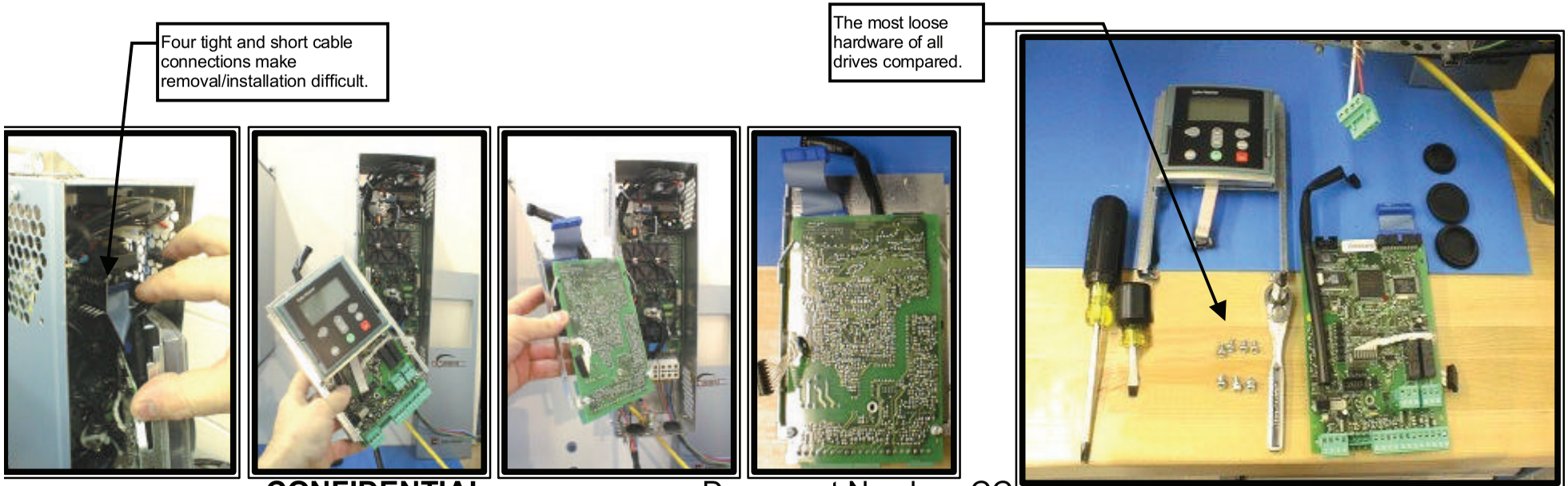






Cutler-Hammer HV9000 Replacing PCB – Comments: This was the most difficult PCB to replace of all the drives compared. Side access screws and exposed power circuitry are concerns. The most difficulty occurred in removal of four very short cable connectors attached to the board. Finger clearance was not adequate to grasp the headers; the cables/wires were grasped to remove the plugs. Installation was more difficult as cables come unplugged while seating others. It is also very easy to improperly connect the main four position I/O plugs into the wrong place on the block. Terminal block numbers needed close attention for correct termination. Seven pieces of loose hardware and three tools combined with difficult cable connections made the HV9000 PCB the most difficult to replace.




Four tight and short cable connections make removal/installation difficult.
The most loose hardware of all drives compared.

G. Keypad

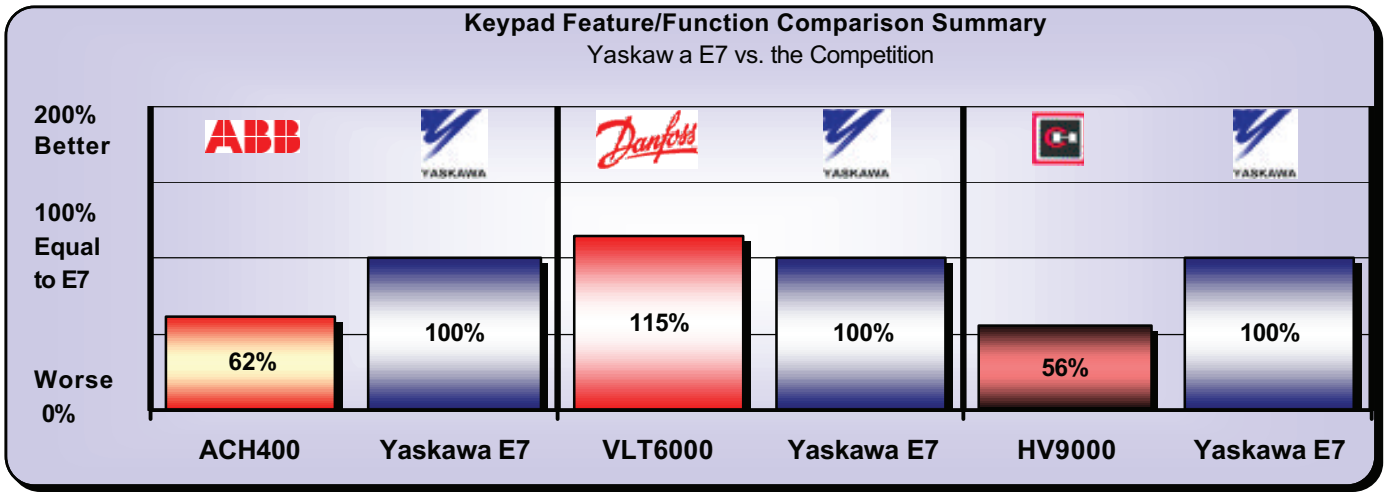
The keypad or digital operator is the drive component the user must become familiar with to configure, operate, adjust and diagnose the drive.

The keypad/digital operator design can simplify or complicate many aspects of user interaction with the drive. Users often form opinions on the product based on how easy it is to operate, configure, monitor status or troubleshoot the drive. In addition, digital operator design can increase or decrease cost of installation or ownership. For example: drive start-up or diagnostic time can be minimized with a easily understood interface that readily conveys information to the user. User exposure to the keypad / digital operator is often limited to equipment set-up or troubleshooting. Good interface design is critical because users often go for long periods without using the keypad. Ideally, the keypad should be able to easily convey information and allow drive configuration without the use of reference documents that may not be readily available. This comparison rates keypad/digital operator ergonomics, configuration and diagnostics capabilities. Some scores are subjective because opinions on desirable features may vary between individuals.

Keypad Feature Comparison Summary

The digital operators were evaluated in 37 different areas or categories. The physical characteristics and functionality of the E7 keypad are well designed. The ABB ACH400 and Cutler-Hammer keypads received the lowest rating when compared to the E7. The Danfoss VLT6000 exhibited some weaknesses in physical design but compensated for this in keypad functionality and ended up with a slightly higher rating than the E7. Overall, the E7 keypad is well placed against the competition.

A detailed explanation of Keypad Feature comparisons is located in **Appendix 3- Keypad Feature Comparison Details.**

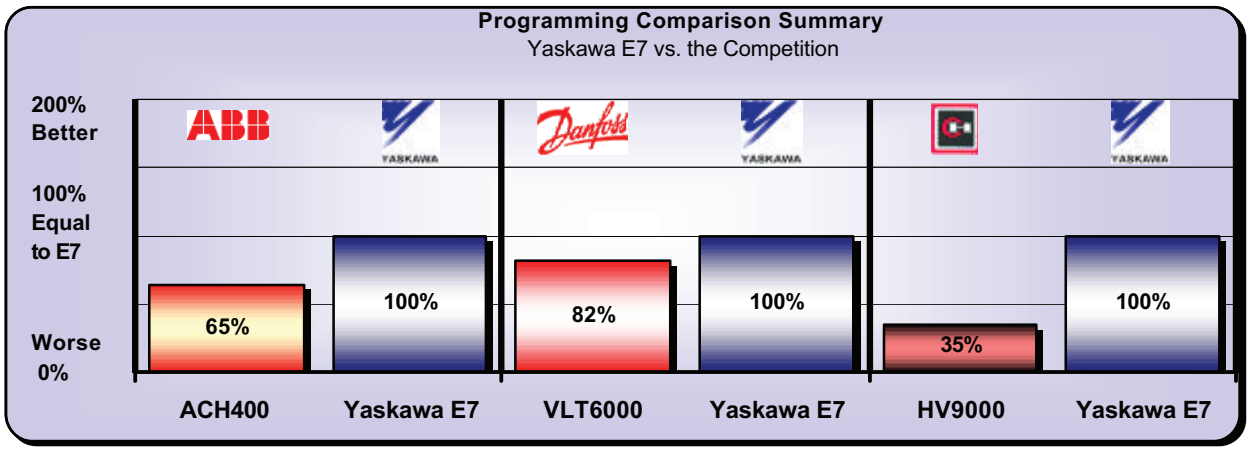


Keypad Photos

YASKAWA ABB Danfoss

H. Programming

An intuitive parameter structure within the drive is critical when dealing with a potentially hundreds of settings. AC drives can posses hundreds of settings. This complexity is a result of the need for drives to be flexible in their application. Typically only 10-20% of drive parameters are used for a majority of applications. How well the parameter structure is configured can influence the usability of the product. Manufacturers typically group less common parameters separately from more commonly used parameters to allow easy navigation and start-up when the drive is first used. How quickly a more common parameter such as (acceleration time) is accessed and adjusted can be an indication of programming ease. The same can be said for how easily a less common parameter is accessed. Some manufacturers provide computer software or other tools to simplify programming. This comparison rates the drives ease of programming for the first time user. It is understood that an interface may become easier to use as one becomes more familiar with it.



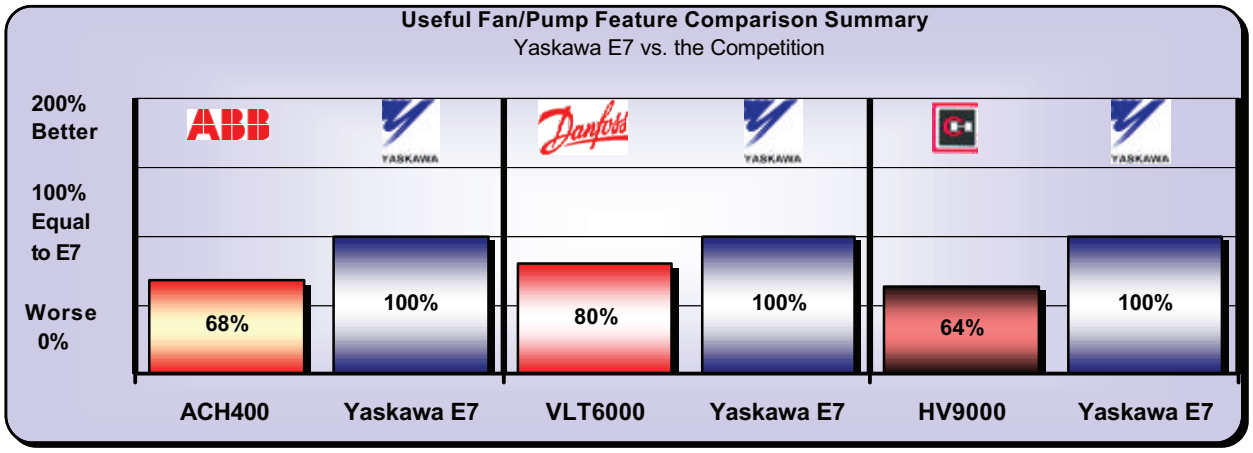
Programming Comparison

Programming of the drive was evaluated using 17 different areas. The E7 had more parameters and more PID adjustments than the competition. In addition, the standard CAT5 cable for keypad connection is available at any Radio Shack. A strong point for the E7 is that the drive can be test run right out of the box by just pressing the HAND key.

Programming comparison details can be found in **Appendix 4 -- Programming Comparison Details.**

I. Useful Fan/Pump Features

The drives in this comparison are designed to meet the needs of the Building Automation System marketplace. A large set of features specific to fan and pump applications is characteristic of a flexible product that is well suited to its market. A large functionality set may also be an indication of the manufacturers industry experience and will help integrate and tailor the drive to its application. These features are mainly designed into the drives software as parameter functions. The drives input/output interface is also considered. This comparison rates the presence of desirable HVAC and pump performance features.



Useful Fan/Pump Feature Comparison

Useful features of the drives are compared in 25 different areas.

Overall, the E7 is the strongest in providing a well rounded useful feature set for fan and pump applications.

E7 vs. ABB ACH400

The ABB drive lacks, motor pre-heat, V/f pattern flexibility and user restorable parameter sets. In addition, Bi-directional speed search and energy saving features are missing from the ABB drive. Automatic energy savings should be standard in a drive targeted for the HVAC market.

E7 vs. Danfoss VLT6000

The E7 has twice as many PID set-up parameters to fine tune PID applications. In addition, the VLT6000 lacks preset V/f patterns and S-Curve accel/decel curves.

E7 vs. Cutler-Hammer HV9000

The HV9000 lacks motor auto-tuning and has limited V/f pattern flexibility. In addition, no run permissive input, bi-directional speed search or automatic energy savings can be found in the HV9000.

Details on Useful Fan/Pump Features can be found in Appendix 5 -- Useful Fan/Pump Feature Details

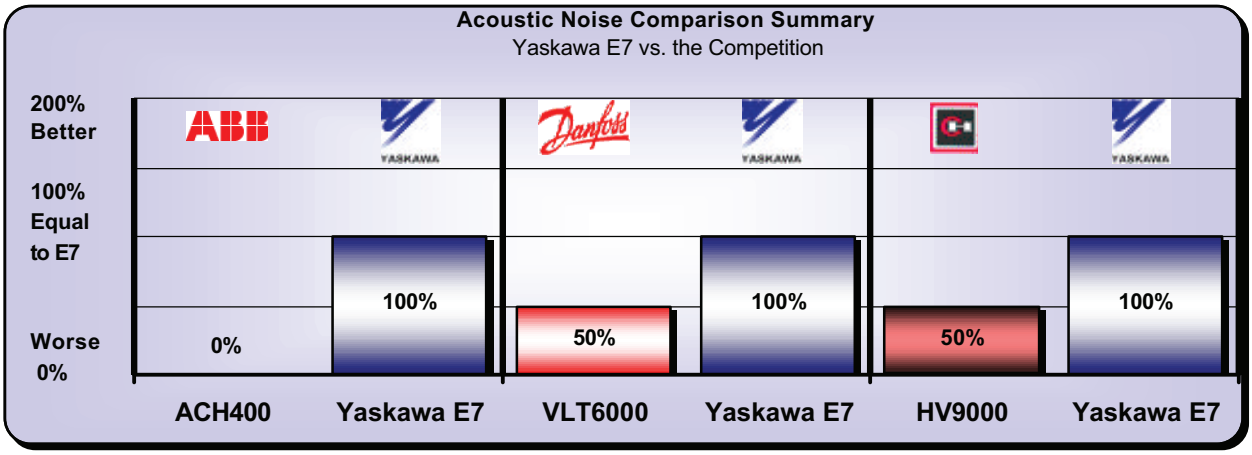
J. Acoustic Noise Considerations

Acoustic noise is an concern in building automation systems. HVAC installations will often be evaluated for noise against Room Criterion Curves (RC). Room Criterion Curves specify acceptable ambient noise levels for many public buildings. Sound and vibration levels of the drive system are influenced by the following parameters:

--Electromagnetic design of the motor
--Control type
--Resonance of the motor's frame structure and enclosure
--Integrity, mass, and configuration of the motor's base mounting structure
--Sound and vibration originating at the coupling between the motor's shaft and the driven load
--Windage

Selecting a quiet drive and motor type can help to reduce the overall ambient Sound Pressure Level of an HVAC system.

This comparison rates drive features that can help mitigate motor electrical noise.



- **Acoustic Noise Comparison**

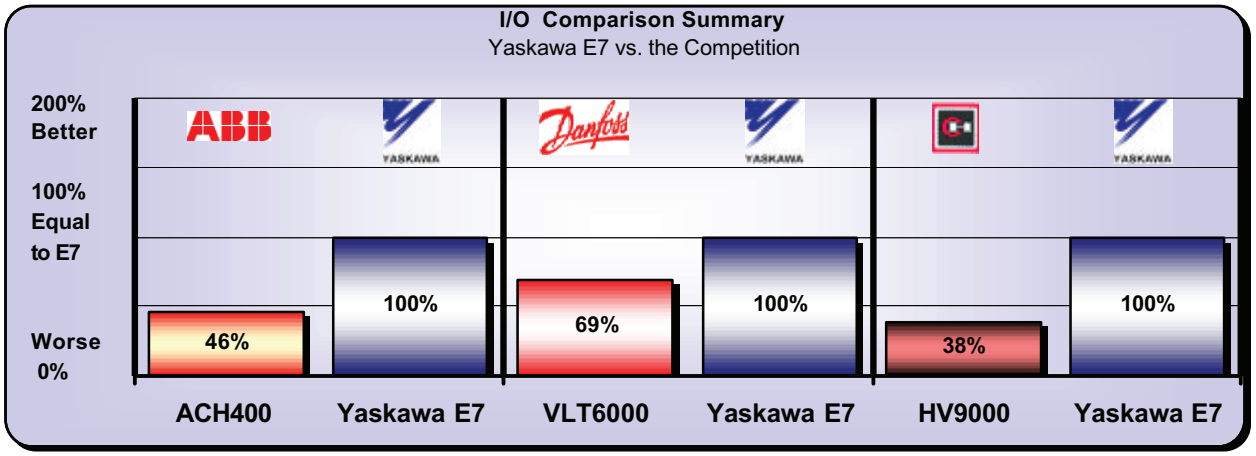
The E7 posseses a higher carrier frequency and special software functionality to help with motor noise in fan/pump applications. The competition typically has lower carrier frequencies on average and requires derating to obtain a carrier greater than 8-10 kHz on most models. The E7 has both a higher carrier and special PWM modulation software to help limit motor noise. (see the table below)

No.	Acoustic Noise Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Special motor noise reduction software/parameter function.	2	Yes -PWM control by moving the peak of the noise to a frequency band in which the human's audibility is poor.	0	Only by increasing carrier frequency to 8khz or asynchronous	2	Automatic Switching frequency modulation, increases carrier only when load is below 60%.	0	Only by increasing carrier frequency
2.	Switching Frequency above 10kHz	2	All 230V models : except 50/60HP & 460V models <10HP & 20-30HP no derating	0	8 kHz or Asychronous w/derating	0	All models defaulted to 4.5kHz and must be derated above 4.5Khz	2	3.6kHz>40HP otherwise 10kHz all other models.all models settable to at least 10khz with only 6 models requiring no derating
	TOTAL SECTION SCORE	**4**	=100%	**0%**	of E7	**50%**	of E7	**50%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

K. Input / Output Interface Features

The drive must interface with either a building management system or a PLC controller. Operation of the drive is usually turned over to a remote system during commissioning. The quantity and flexibility of digital and analog input/output points can allow the drive to perform functions normally performed by costly add-on devices. A flexible I/O often allows the system to be used for more than just motor speed control. For example: A time delay relay built into the drive may be used to delay drive start without adding a separate relay to perform this same function. This comparison rates the quantity of I/O points as well as the number of programmable functions.



Input / Output Interface Comparison

The E7 compares very favorably to the competition in both the quantity of I/O points as well as the flexibility of the I/O to be programmed to the applications needs.

No.	***Standard I/O Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Analog Input Qty	2	2 each/ 1 is programmable	4	2 each/ 2 are programmable	4	3 each, (2voltage, 1current) / 3 are programmable	4	2 each/ 2 are programmable
2.	Voltage Analog Input Converts to mA input	2	Yes	2	Yes	0	No	0	No
3.	Analog Output Qty	2	2 each/ 2 are programmable	0	1 each/ 1 is programmable	2	2 each/ 2 are programmable	0	1 each/ 1 is programmable
	AO selectable , Voltage or Current	2	Yes	0	No- mA only	0	No	0	No
4.	Digital Input Qty	2	7 each/ 5 are programmable	0	5 each/ 5 programmable	4	8 each/ 8 are programmable	0	6 each/ 6 are programmable
5.	Digital Input Sinking/Sourcing	2	Yes	0	NPN only	0	No	2	Yes
6.	Digital Input External Supply Allowed	2	Yes	0	No	2	Yes	0	No
7.	Digital Output Relay Qty	2	3 each/ 2 are programmable	0	2 each / 2 are programmable	0	2 each/ 2 are programmable	0	2 each/ 2 are programmable
8.	Open-collector Qty	2	0	2	0	2	0	4	1 each
9.	Number of programmable functions AI	2	7 different functions	0	3 different functions	0	4 different functions	0	**5 different functions
10.	Number of programmable functions AO	2	18 different functions	0	17 different functions	0	*5 different functions	0	**16 different functions
11.	Number of programmable functions DI	2	59 different functions	0	11 different functions	0	25 different functions	0	**12 different functions
12.	Number of programmable functions DO.	2	27 different functions	4	32 different functions	4	*29 different functions	0	**26 different functions
	TOTAL SECTION SCORE	**26**		**46%**		**69%**		**38%**	

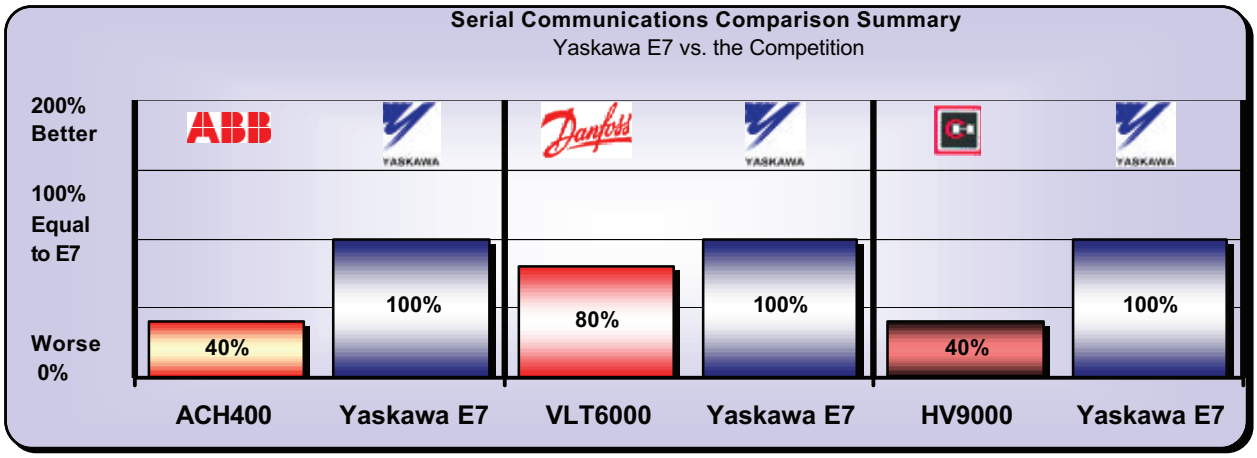
Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)
***Note: The VLT6000 analog outputs also function as digital DC outputs.**
**** Note: The VLT6000 "Pump and fan control Application" was used to determing programmable functions, this application seemed to have the most functions of all the HV9000 applications. ***Note : Expandable I/O is not considered in this evaluation**

L. Serial Communications

With the increasing need for control and integration of automation devices in facility information systems, the flexibility and ease of communication capabilities in adjustable speed drives is vital. A number of factors should be considered when looking at communications, for example;

- The drive may need to be controlled by programmable controllers or by a building management system.
- The drive's communications capabilities should be flexible enough to meet present and future needs.
- Communications links should be easily accessible and simple to install.

This comparison rates the number of supported protocols and if these are built-in or standard with the drive.



Serial Communication Comparison

The E7 is significantly stronger than ABB or Cutler-Hammer in the serial communications comparison. Built-in protocols such as Landis and Johnson Controls give the E7 a competitive edge. The Danfoss VLT6000 chooses to support their own proprietary protocol instead of Modbus as standard. The VLT6000 also does not have a built-in RS-232 connection like the E7.

No.	Serial Communications Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Built-in RS-232	2	Yes	0	No	0	No	2	RS-232
2.	Built-in RS-485	2	Yes	2	Yes	2	Yes	0	No
3.	Built-in Modbus	2	Yes	2	Yes	0	No	0	No
4.	Built-in Johnson Controls Metasys N2	2	Yes	0	No	2	Yes	0	No
5.	Built-in Seimens/Landis APOGEE FLN	2	Yes	0	No	2	Yes	0	No
6.	Built-in Other	0	No	0	No	2	Yes (Danfoss protocol)	2	Yes
TOTAL SECTION SCORE		**10**	= 100%	**40%**	of E7	**80%**	of E7	**40%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

M. Harmonic, EMI/RFI and Output dV/dT Mitigation

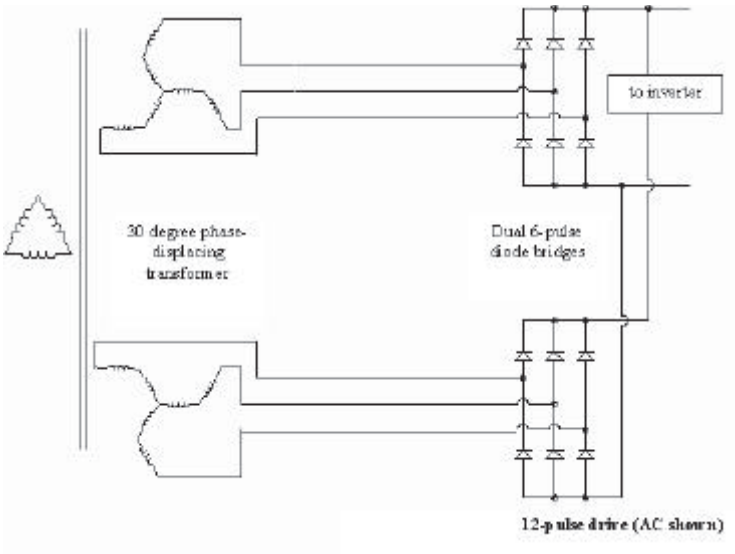
Providing cost effective power quality solutions are important in a drive product.
To minimize harmonics problems, an increasing number of ASD manufacturers are packaging harmonics-mitigating equipment (such as line reactors or isolation transformers) with drives. These features can allow users to enjoy the full benefits of power factor improvement. In addition, this added equipment can significantly reduce the impact of ASD-generated harmonics on other electronic equipment--a benefit that should be especially attractive to value-conscious commercial and industrial users. This comparison rates the competition against the E7 in providing power quality solutions.

A Primer on Power Quality solutions for AC Drives

How are power line harmonics created with an AC drive?
Since the DC filter inside of the drive is capacitive, the AC line current waveform and its associated harmonic frequencies are dependent for their shape and magnitude on the total circuit inductance of the AC lines feeding the drive. If the AC lines are very "stiff" with respect to the drive kVA (i.e. low inductance, high short circuit current capability), the line current waveform will have a poor "form factor" and be very rich in harmonic frequencies. If the AC lines are "soft" with respect to the drive KVA rating (i.e. high inductance, low short circuit current capability), the line current wave form will have a better "form factor" and the harmonic content will be lower. The larger the DC link choke inside the drive, the less effect the AC line inductance will have on the line current wave.

The 12-pulse drive
The 12-pulse drive approach used to improve power quality over a 6 pulse drive. A standard 6-pulse SCR or diode rectifier is replaced with two 6-pulse rectifiers, each fed by one secondary of a special transformer which phase displaces the two secondaries by 30 electrical degrees. The DC outputs of each of the two 6-pulse rectifiers are then connected in parallel or in series with each other (parallel being the more common).

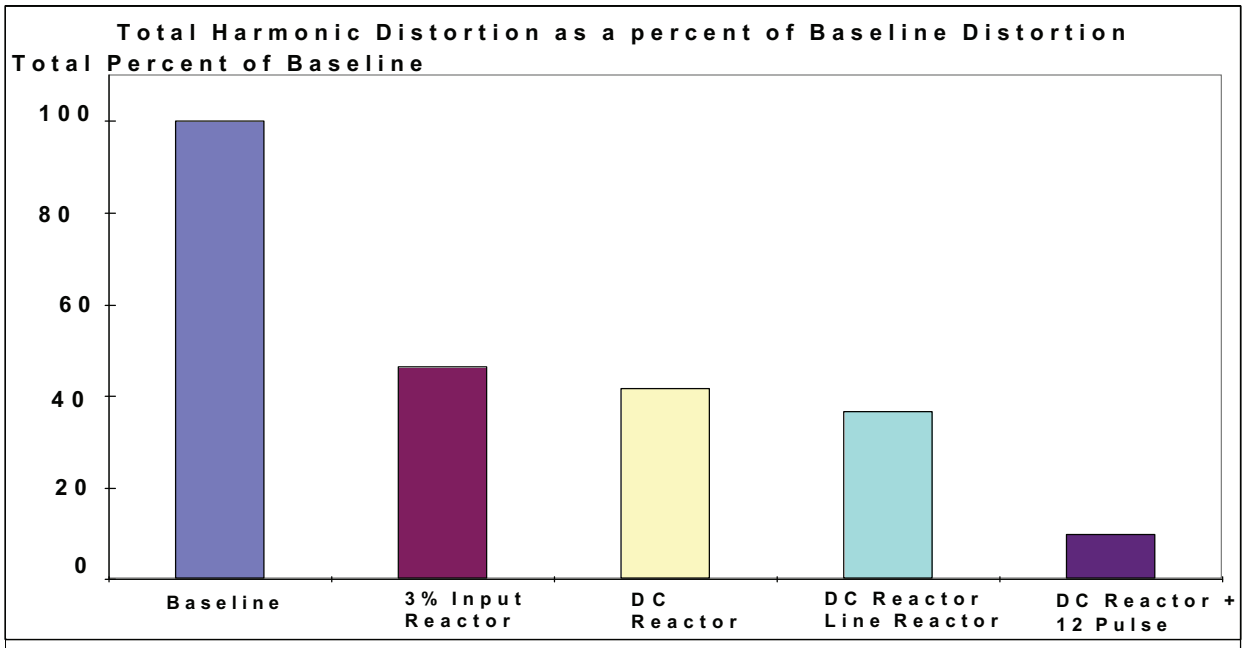
The input current to each of the two 6-pulse rectifier bridges will contain all of the harmonic frequencies associated with a standard 6-pulse drive. However, the 5^{th}, 7^{th} and 17^{th}, 19^{th} and 29^{th}, 31^{st} etc. harmonic currents from each bridge are 180 electrical degrees out of phase with each other causing them to cancel in the transformer primary. This results in a lower total harmonic distortion because the transformer input current waveform contains only the 11^{th}, 13^{th}, 23^{rd}, 25^{th}, 35^{th}, 37^{th} etc.



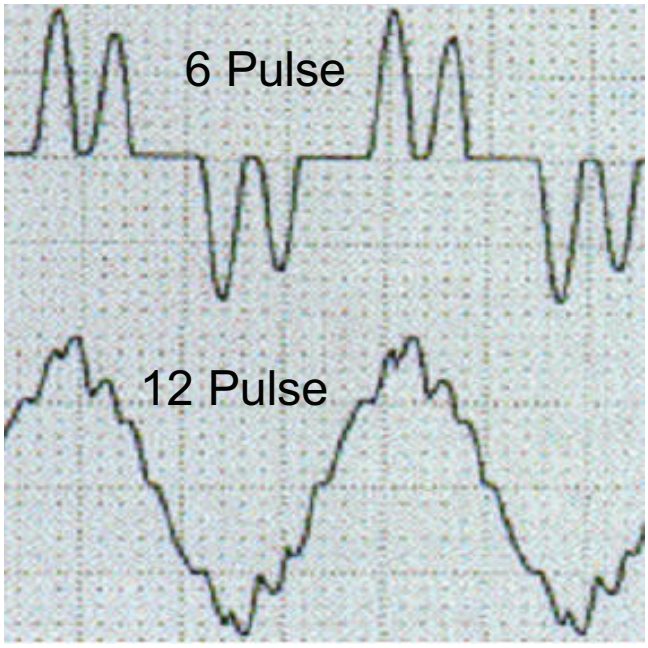
harmonics. In all other aspects, the 12-pulse drive operates exactly in the same manner as the 6-pulse version of the same topology does.

The chart below shows how using different hardware components affect power line total harmonic distortion. This chart remains essentially the same for all drives possessing an AC to DC diode bridge rectifier.

E7 drives greater than 30 HP contain a 12-pulse diode bridge.

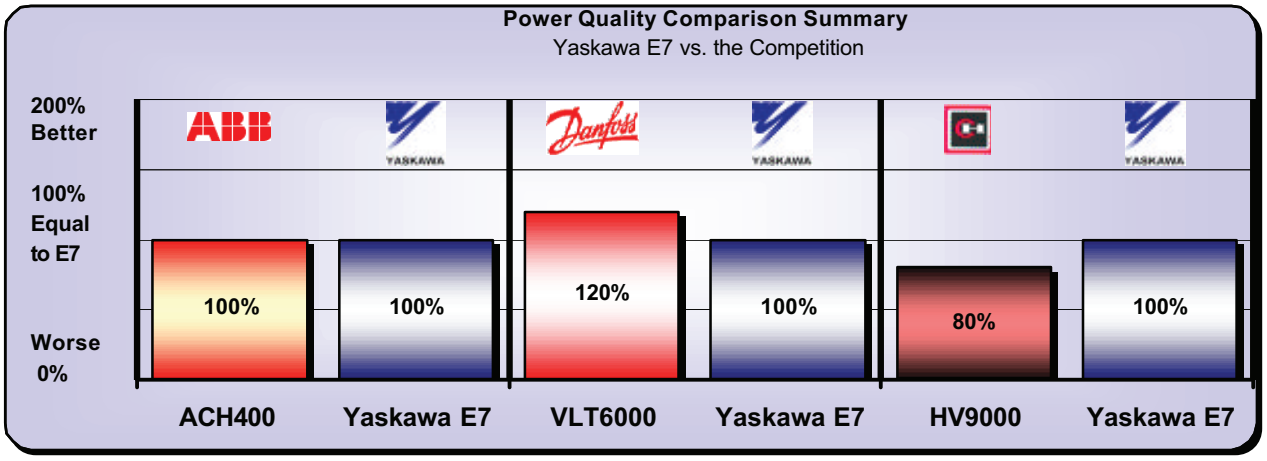


Countermeasure	BaseLine	3% Input Reactor	DC Reactor	DC Reactor + Input Reactor	DC Reactor + 12 Pulse
Harmonic THD as	100% Load	100% Load	100% Load	100% Load	100% Load
% of Baseline THD	**100**	**46.3**	**41.6**	**36.6**	**9.86**
True PF (VA / W)	0.63	0.9	0.85	0.91	0.95
Countermeasure for 25/30 Hp @ 460 VAC					



Harmonic, EMI/RFI and Output dV/dT Mitigation Comparison

The E7 has an advantage, when properly applied, the 12-pulse diode bridge in the E7 allows the E7 to reduce harmonic distortion to the lowest levels. In addition, standard MOV protection and good control of output dv/dt make the E7 a smart choice for building automation applications. Danfoss provides the strongest competition in this area with built-in bus chokes for all models.

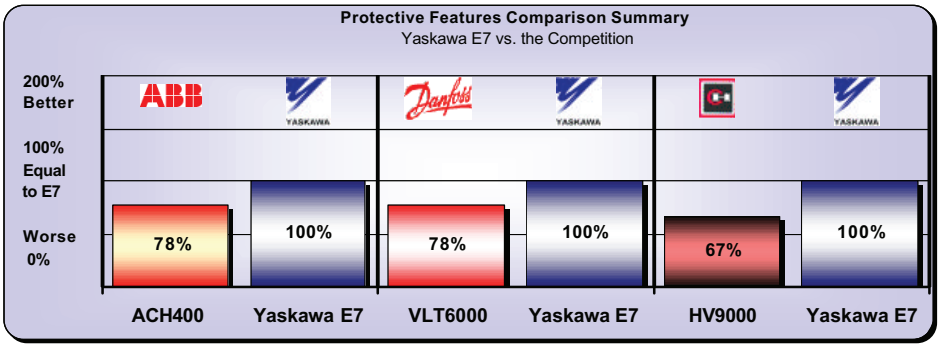


No.	Power Quality Comparison-Built-in Countermeasures	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	DC Link choke terminals on select models	2	</= 30 Hp	4	Not required due to built in choke for all models	4	Not required due to built in choke for all models	4	Not required due to built in 3 phase reactor all models
2.	Built-in 12-pulse diode bridge	2	12 pulse diode bridge >/= 30 HP	0	No	0	No	0	No
3.	Built-in 3% positive DC link choke	2	3% Std. Positive Link choke >/= 30 HP.	4	3% Std. Positive and Negative Link choke all models	4	3% Std.Positive and Negative DC link choke all models	2	3 Phase 3% internal AC choke standard above 3 HP 240V & 5 HP 480V
7.	Output DV/dT less than 5 kV/us	2	Yes	0	No	2	Yes	2	Yes
8.	Surge protection	2	MOV's	2	MOV's	2	MOV's	0	No
	TOTAL SECTION SCORE	**10**	= 100%	**100%**	of E7	**120%**	of E7	**80%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

N. Protective Features

Built –in protective features are important to protect both the drive and connected equipment from damage. The ability of the drive to protect itself during abnormal conditions can give the operator valuable time to investigate a problem before equipment damage can occur. The ability of the drive to restart/reset automatically can help keep down-time to a minimum. This comparison rates the competition against the E7 in available protective features.



Protective Features Compared

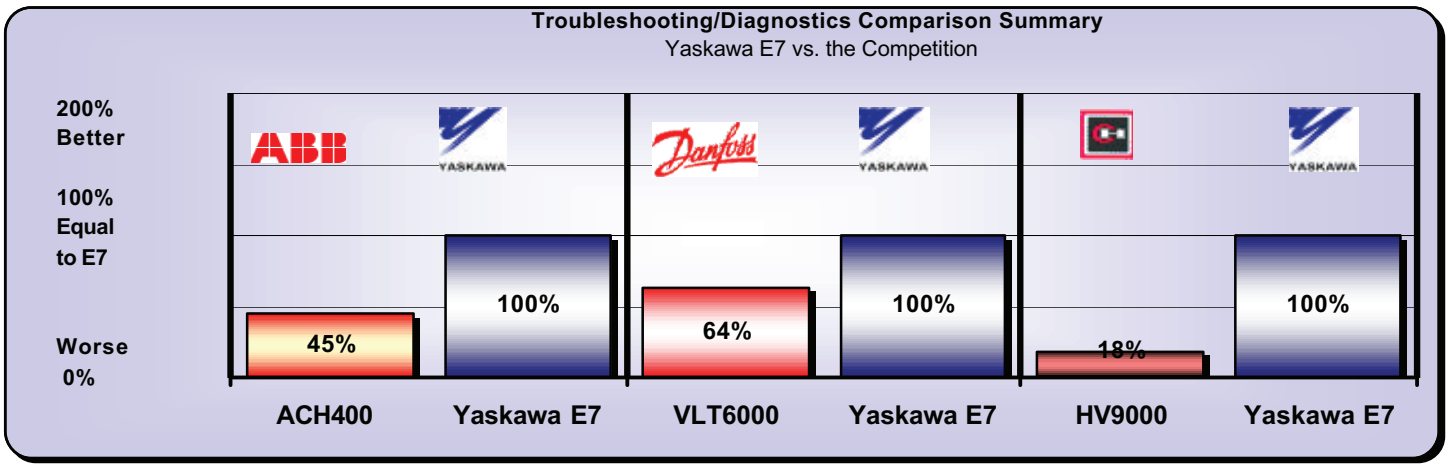
The E7 provides some very useful protective features that are not found in the competition. A DC bus charge indicator can warn maintenance personnel of dangerous voltage potential in the drive.The ability to limit an inadvertent reverse direction command via software can prevent equipment damage. Knowing how long a cooling fan on the inverter has been in service can assist in preventive maintenance. Automatic frequency or speed fold back under heavy loads can keep the drive running when other drives fault.

No.	Protective Features Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	UL motor overload	2	Yes	2	Yes	2	Yes	2	Yes
2.	Input signal loss	2	Yes	2	Yes	2	Yes	2	Yes
3.	Input and Output phase loss	2	Yes	2	Yes	2	Yes	2	Yes
4.	Under/Over load-torque protection	2	Yes	2	Yes	2	Yes	2	Yes
5.	DC bus charge indicator	2	Yes	0	No	0	No-only "ON" indicator	0	No
6.	Std. DC bus or AC line fuse	2	Yes	0	No	2	Yes	0	No
7.	Inertia ride thru on power loss	2	Yes	2	Yes	2	Yes	2	Yes
8.	Reverse prohibit function	2	Yes	2	Yes	0	No	0	No
9.	Parameter lockout	2	Yes	2	Yes	2	Yes	2	Yes
10.	65k short circuit withstand	2	Yes	2	Yes	2	Yes	0	No--- Only 35K to 3HP 230V and to 5HP 480 Remaining frames have100k
11.	Isolated I/O	2	Yes	2	Yes	2	Yes	2	Yes
12.	Cooling fan hours recorded	2	Yes	0	No	0	No	0	No
13.	Input MOV's	2	Yes	2	Yes	2	Yes	2	Yes
14.	Overvoltage control of decel ramp	2	Yes	2	Yes	2	Yes	2	Yes
15.	Digital operator loss fault	2	Yes	2	Yes	0	No	2	Yes - Not programmable
16.	Heat sink overtemp , speed/carrier fold back	2	Yes	0	No	2	Yes	0	No
17.	Ground Fault	2	Yes	2	Yes	2	Yes	2	Yes
18.	Short Circuit	2	Yes	2	Yes	2	Yes	2	Yes
	TOTAL SECTION SCORE	**36**	**= 100%**	**78%**	of E7	**78%**	of E7	**67%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

O. Troubleshooting

A drive product that provides good diagnostics and troubleshooting tools can reduce the cost of ownership and installation. Effective and easy to understand diagnostics make it easy for maintenance personnel to maintain and diagnose system problems in a timely manner. This comparison rates the competition against the E7 in troubleshooting and diagnostic capabilities.



See Appendix 6 – Troubleshooting and Diagnostics Comparison for details

Troubleshooting

The E7 has the richest set of diagnostic and troubleshooting tools, well beyond the competition. Yaskawa has dedicated more manual pages to diagnostic information than any other competitor. Detailed fault code explanation provided by Yaskawa ensures there are no surprises with the E7. The E7 has such simple features that make a big difference. Such as the ability to require the user toggle the run command after some faults to prevent accidental injury to personnel or damage to equipment. Yaskawa's technical support capabilities are well documented within the manual unlike the competitors that only provide a phone number.

Appendices

Appendices 1 and 2 are omitted intentionally

P. Appendix 3- Keypad Feature Comparison Details

No.	Keypad Feature Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Display type	2	LCD 5 lines 64 total chars, 14.08 sq cm	0	LCD 2 lines 30 total chars, 13.5 sq cm	2	LCD 4 lines 68 total chars, 15 sq cm	2	LCD 4 lines 64x128 pixel , 16 sq cm
2.	Quantity of keys	2	10	0	8	4	14	0	8
3.	Environmental rating	2	IP20	2	IP20	4	IP-65 on front	2	IP20
4.	Cable connection	2	RJ-45 Std.	0	Custom 7 pin	2	DB-9 Std.	2	DB-9 Std.
5.	.Removal/Installation	2	Simple	0	Pins easily bent	2	Simple	2	Simple
6.	Surface area	2	84 sq. cm	0	70 sq. cm.	4	108.7 sq.cm	4	95 sq.cm
7.	Key spacing	2	2.75 sq. cm per key	0	2.40 sq. cm per key	4	3.14 sq. cm per key	0	2.7 sq. cm per key
8.	Button feel	2	Fair	4	Good	4	Excellent	4	Good
9.	Indicators	2	7 LED's	0	2 LED's	0	3 LED's	0	0 LED's
10.	Display readability	2	Good	2	Good	2	Good	2	Good
11.	Alternate keypad models	2	Yes	2	Yes	2	Yes	2	Yes
12.	Starting a motor from keypad	2	Hand Button	0	Default is Remote /terminal control. Must press and hold Loc/Rem to put drive in local. Then use start and stop buttons.	2	Hand button	0	Must press "Enter for 2 secs then once again then "Start" button.
13.	Qty. of initial parameters to set for motor run	2	1 ea- Motor rated FLA- for standard 460/230V motors. Manual describes 17 steps for clarity however pressing the HAND button starts drive right out of the box.	0	Ten initial steps, Eight parameters for motor data the jumper Terminals 9 to 12 required.	0	6 Initial Parameter entry steps	0	6 Initial Parameter entry steps
14.	Effort to change accel time.	2	12 key presses to access the accel parameter. A bit difficult to get to thru the Quick Menu, Programming menu was used.	4	Seven key presses to access	4	10 key presses to access accel parameter	2	6 steps- although the manual was needed to understand navigation to find the parameter
15.	Starting motor from terminal block I/O	2	2 steps Press Auto Key- then start key	2	2 steps Press Auto Key- then start key	2	2 steps- Auto start Key	0	Hand toggle key then Start key. Terminal Block Jumper Required to start the drive in HV Basic.
16.	Access to full parameter sets	2	5 main menus -no unlocking required to access Programming menu with all parameters	0	Small set of Basic initially available. Menu function LG makes full set available.	2	Extend. Menu Key one touch.	0	Several different Applications available in the HVREADY Package: **Basic, Standard, LOC/REM Control, Multi-Speed, PI-control, Multi-purpose control, Pump and Fan.** Somewhat confusing to unlock applications.
17.	HOA keys?	2	Yes H-O-A	2	Yes H-O-A	2	Yes H-O-A	0	Only one toggle key
18.	Parameter copy function	2	Yes	2	Yes	2	Yes W/keypad	0	Optional
19.	Parameter lockout.	2	Yes	2	Yes	2	Lock w/DI or parameter.	2	Yes
20.	Ease of Programming	2	Initial display is 2 monitors an Freq Ref. The Quick menu has 60 + parameters and many PID setting parameters.	2	Setting to display all parameters required manual.Parameters in 24 different groups 180 parameters total, Initialll only displays 25 basic parameters.	2	Manual was required to understand the different display modes 1-4. Otherwise very intuitive.	2	8 menus leading to sub menus.

Appendix 3- Keypad Feature Comparison Details (continued)

No.	Keypad Feature Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
21.	Intuitiveness	2	It is initial unclear that pressing the MENU button repeatedly cycles thru menus. Otherwise parameter setting seems straight forward.	0	Not very intuitive	2	No problems with clearly labeled buttons and menus	0	Not very Intuitive
22.	Access to monitor values	2	2 monitors and Freq Ref are displayed initially. Scrolling up cycles sequentially through the monitors. Selecting three of choice requires leaving the initial screen and setting two other parameters.	2	Four monitors at a time . 3 small text and 1 large text.	2	Four Monitors at a time, the drive has "Display Mode" 4 at one time, 3 small text and 1 large text. Selecting four of choice requires leaving the initial screen and setting two other parameters.	0	One monitor at a time No monitor Key-- on STD operator
23.	Number of available monitors	2	32	2	33	0	27 possible monitors	0	24
24.	Types of monitor displays. Bits, graphs, analog, digital etc.	2	Text and Bit values	0	Text only	4	Text, Binary for I/O , BarGraph for references.	2	Text -Icon indicators on Standard operator LCD
25.	Monitor display flexibility	2	Very flexible- but some manual reading required to configure.	2	4 fixed values at same time- amps, torque ref, setpoint 1 selectable three fixed	2	Holding "Display Key for 1 sec causes engineering units to be spelled out temporarily for easy interpretation.Very flexible- but some manual reading required to configure	0	Less intuitive-No "Monitor Button" Standard HOA kypd only allows one monitored parameter ata a time. Optional HV Multi-line or HV Graphic is required for more
26.	Simultaneous operation , adjustment , monitoring	2	No- Only Freq Ref Setting with two other monitors	2	No -Only Freq ref w/fixed amps and torque display at same time	4	Yes- 3 monitors and one parameter setting	2	No
27.	Energy Monitoring El time, kw,kwh	2	PWR , KWH, HOURS, Mwh	2	PWR -KW, KWH, HOURS, Mwh	2	KW,KWH,HP, HOURS	2	MW HOURS, KW HOURS, MOTOR PWR%,
28.	Fault indications	2	Alarm LED	2	LED blinking and Fault Text on LCD display. 2	4	Two from LED's - Alarm ,Warning, LCD displays Fault Text.	0	LCD Displays Fault code and description, upon fault..
29.	Access to fault displays	2	Fault code is displayed automatically	2	Fault code is displayed automatically	2	Faults Automatically displayed.	2	Faults Automativcally Displayed
30.	Fault history and trending	2	Good- Last 10 faults stored with time, 12 logged drive conditions at time of fault.	0	Poor- Last three codes stored. No logging or trending available	2	Good- Data Log - 20 different parameters are logged every 160ms and recorded- However the data is lost if drive is powered down. Fault Log -- Time, trip value, and options to reset kWh or running hours.	0	Poor- Scroll to Fault Menu M6, only last 9 faults listed no data at time of fault available.
31.	Usability of fault display	2	Good	2	Good -Fault code is displayed with short text of fault spelled out. Data available thru serial comm	2	Good- Spells out fault name Data is also available thru serial communication.	0	Poor-Text spells out approx two words of the fault name. No operation data captured for troubleshooting.

Appendix 3- Keypad Feature Comparison Details (continued)

No.	Keypad Feature Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
32.	Special Features	2	Parameter range and default value are displayed for the user when changing a parameter.	2	Kypd displays factory test date	2	Nameplate Data , Installed Options and Power Component ID is Available thru display.	2	Three possible Digital Operators Available: HV Multiline-STD Type, HVGraphic(has copy function), HVMultiline-w/HOA (has HOA button)
33.	Fault Types	2	Excellent--41 faults and 18 alarms some programmable, 15 adjustment or tuning specific faults	0	28 fault codes,34 warning alarms fixed	0	28 different faults and 29 warnings	0	28 faults, 9 fixed warnings
34.	Fault resetting	2	Reset Key , cycle pwr. SAFE: Run command must be removed before fault reset.	0	Reset Key , cycle pwr DANGER: The drive will run without toggling the run command after fault reset	2	Reset Key , cycle pwr	0	Reset Key , cycle pwr DANGER: The drive will run without toggling the run command after fault reset
35.	Remote Mounting	2	10 feet	2	10 feet	2	10 feet	2	10 feet
36.	Components /parts required	2	Std Cat 5 cable w/ RJ45	0	Special cable w/ non-standard connectors.	0	Custom serial cable w/DB9 both ends and door mounting kit.	0	Custom serial cable w/DB9 both ends and door mounting kit.
37.	Environment	2	IP00	2	IP00	4	IP65 on front of operator only	2	IP00
	TOTAL SECTION SCORE	**74**	=100%	**62%**	of E7	**114%**	of E7	**54%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

Q. Appendix 4 -- Programming Comparison Details

No.	Programming Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Settable Parameter quantity.	2	231	0	176	0	153	0	Average 120 per application,
2.	Parameter levels	2	(63 Quick)(168 Programming)	2	(23 Basic)(153 Full)	2	(12 Quick)(153 Extended)	2	HVReady Software Containing 6 different applications. **HV Basic**=27 parameters. **Standard Application**=8 Groups with 65 parameters. **Loc/Rem Application**=8 Groups with 113 parameters. **Multi-Step Speed Control Application**=8 Groups with 115 parameters. **PI-Control**
3.	Starting a motor from keypad	2	Hand Button	0	Default is Remote /terminal control. Must press and hold Loc/Rem to put drive in local. Then use start and stop buttons.	2	Hand button	0	Must press "Enter for 2 secs then once again then "Start" button.
4.	Qty. of initial parameters to set for motor run	2	1 ea- Motor rated FLA- for standard 460/230V motors. Manual describes 17 steps for clarity however pressing the HAND button starts drive right out of the box.	0	Ten initial steps, Eight parameters for motor data the jumper Terminals 9 to 12 required.	0	6 Initial Parameter entry steps	0	6 Initial Parameter entry steps
5.	Effort to change accel time.	2	12 key presses to access the accel parameter. A bit difficult to get to thru the Quick Menu, Programming menu was used.	4	Seven key presses to access	4	10 key presses to access accel parameter	2	6 steps- although the manual was needed to understand navigation to find the parameter
6.	Starting motor from terminal block I/O	2	2 steps Press Auto Key- then start key	2	2 steps Press Auto Key- then start key	2	2 steps- Auto start Key	0	Hand toggle key then Start key. Terminal Block Jumper Required to start the drive in HV Basic.

Programming Comparison Details (continued)

No.	Programming Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
7.	Access to full parameter sets	2	5 main menus -no unlocking required to access Programming menu with all parameters	0	Small set of Basic initially available. Menu function LG makes full set available.	2	Extend. Menu Key one touch.	0	Several different Applications available in the HVREADY Package: **Basic, Standard, LOC/REM Control, Multi-Speed, PI-control, Multi-purpose control, Pump and Fan.** Somewhat confusing to unlock applications. Additional parameters are available with Application Packages, The Drive hides all except only BASIC Application parameters at first. Other parameter groups are available by unlocking the Application package lock.
8.	HOA keys?	2	Yes H-O-A	2	Yes H-O-A	2	Yes H-O-A	0	Only one toggle key for HOA not separate keys.
9.	Ease of Programming	2	Initial display is 2 monitors an Freq Ref. The Quick menu has 60 + parameters and many PID setting parameters.	2	Setting to display all parameters required manual.Parameters in 24 different groups 180 parameters total, Initialll only displays 25 basic parameters.	2	Manual was required to understand the different display modes 1-4. Otherwise very intuitive.	2	8 menus leading to sub menus.
10.	Intuitiveness	2	It is initial unclear that pressing the MENU button repeatedly cycles thru menus. Otherwise parameter setting seems straight forward.	0	Not very intuitive	2	No problems with clearly labeled buttons and menus	0	Not very Intuitive
11.	Usability of fault display	2	Good	2	Good -Fault code is displayed with short text of fault spelled out. Data available thru serial comm	2	Good- Spells out fault name Data is also available thru serial communication.	0	Poor-Text spells out approx two words of the fault name. No operation data captured for troubleshooting.
12.	Copy Function	2	Yes	2	Yes	2	Yes	0	Optional
13.	PID set-up parameters	2	29 each	0	20 each	0	15 each	0	Approx 11 each
14.	Parameter Heirarchy	2	5 main menus with 36 sub menus under Programming	2	Quick menu, Full Menu w/24 sub menus	2	Quick Menu 12 parameters)(Extended Menu divided into 8 Sub Groups)	2	See above
15.	Remote keypad cable	2	Standard CAT5	0	Custom	0	Custom	0	Custom
16.	Upload/Download Tool	2	Drive Wizard	2	Drive Window	2	VLT Software Dialog	2	HV Drive
17.	Tool Required components	2	Custom DB9 to RJ45 cable	2	Special Cable	2	Danfoss Cable	2	C-H cable
	TOTAL SECTION SCORE	**34**	=100%	**65%**	of E7	**82%**	of E7	**35%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

R. Appendix 5 – Useful Fan/Pump Feature Comparison Details

No.	Useful Fan/Pump Feature Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	PID	2	Yes	2	Yes	2	Yes	0	PI control only -no D function.
2.	PID set-up parameters	2	29 each	0	20 each	0	15 each	0	Approx 11 each
3.	Inverse PID?	2	Yes	2	Yes	2	Yes	2	Yes
4.	PID, sleep/snooze	2	Yes		Yes		Yes		No
5.	Dual Feedback?	2	Yes	2	Yes	2	Yes	2	Yes-" 2 actual values"
6.	Square root function?	2	Yes	2	Yes	2	Yes	0	No
7.	Feedback Loss	2	Yes	2	Yes	2	Yes	2	4-20ma input only and only when < 4ma
8.	Motor pre-heat	2	Yes- infinite	0	Pre-Magnetizing 0-25 secs	2	Yes- infinite	2	DC Injection Operates after stop until contact is open .
9.	Motor Tuning	2	Yes- Stationary	2	Yes- Stationary	2	Yes -Stationary AMA feature	0	No
10.	V/Hz pattern flexibility	2	Custom Available 14 preset 1 custom	0	Only 2 Presets- Linear and Squared	0	No Preset Patterns	0	3 selections : Linear, squared, programmed w/ 3 points on the curve.
11.	Stall prevention	2	Yes	2	Yes	2	Yes-Current Limit	2	Yes- Current limit
12.	Restorable User Parameter Settings	2	Yes- 1 programmable user set-up	0	No	2	Yes- Four programmable user set-ups, Transferable via DigiOP to other drives.	2	Yes- 2 sets of storable user parameters.
13.	Predefined Application Settings	2	No	4	Yes- Four groups HVAC, Floating Point, PID, Pump Fan Control.	2	No	4	Yes- Six different predefined-application parameter groups
14.	Power-loss ride-thru	2	Yes 2 secs	2	Yes-using motor inertia- 500ms	2	Yes- Time is KVA dependent(time not listed)	2	Yes- Motor inertia ride thru.Trips @65% of input Voltage-
15.	Run Permissive Input	2	Yes	2	Yes	2	Yes	0	No
16.	Auto restart w/ contact closure on final attempt	2	Yes	2	No	2	No	2	No

Appendix 5 – Useful Fan/Pump Feature Comparison Details (continued)

No.	Useful Fan/Pump Feature Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
17.	Settable Auto Restart Attempt Interval	2	Yes 0-600 secs	2	Yes 0-3 secs	2	Yes 0-600 secs	2	Yes Time between attempts is Trial Time/Number of Tries. EX: 6000 secs/10 Tries=600secs between attempts.
18.	Bi-Directional speed search	2	Yes	0	No-DC Injection Used to stop motor first.	2	Yes	0	No DC inj max time @ start = 25 secs
19.	Anti-wind-milling function	2	Only thru -DC Injection at start	2	Only thru -DC Injection at start	2	Via Motor Preheat DC-Curr.	2	Only thru -DC Injection at stop
20.	Critical frequency rejection	2	Yes 3 ea	0	Yes 2 ea	2	Yes 4 ea	2	Yes-3 ea
21.	Up/Down Floating Point Control	2	Yes	2	Yes	2	Yes	2	Yes
22.	S-curve accel	2	Yes - fully adjustable-separate accel/decel	0	Yes 3 fixed curve selections-not fully adjustable	0	No	0	Yes- Accel/Decel must be same--not fully adjustable
23.	Energy savings features	2	Yes	0	No	2	Yes- AEO function	0	No
24.	Transmitter power Supply	2	Yes +24VDC up to 100ma-digital inputs may use 8 ma each up to 64ma	2	Yes +24VDC up to 250ma	2	Yes +24V 200ma supply	2	Yes +24V 100ma supply
25.	Braking the motor, DC Inj	2	Yes- Start or stop	2	Yes-Start or stop	2	Yes@ start/stop	2	Yes-start/stop
	TOTAL SECTION SCORE	**50**	=100%	**68%**	of E7	**84%**	of E7	**64%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

S. Appendix 6 – Troubleshooting and Diagnostics Comparison Detail

No.	Troubleshooting/Diagnostics Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
1.	Manual pages dedicated to diagnostics.	2	Excellent- 24 pages	0	5 pages	0	7 pages	0	4 pages
2.	Access to test points	2	Access to I/O and power connections is good.	2	Access to I/O and power connections is good.	2	Access to I/O and power connections is good.	0	Terminal screws face downward making I/O block access more difficult.
3.	Fault code explanation	2	Excellent- Probable cause and corrective action in separate columns. Separate troubleshooting section in the manual as well as fault description section.	0	No trouble shooting section only display value and description,	0	No trouble shooting section onlt display value and description,	0	Separate columns for probable cause and "Check" howver no dedicated troubleshooting section.
4.	Fault indications	2	Alarm LED	2	LED blinking and Fault Text on LCD display. DANGER: The drive will run without toggling the run command after fault reset.	2	Two from LED's - Alarm ,Warning, LCD displays Fault Text.	0	No LED. LCD Displays Fault code and description, upon fault. DANGER: The drive will run without toggling the run command after fault reset.
5.	Access to fault displays	2	Fault code is displayed automatically	2	Fault code is displayed automatically	2	Faults Automatically displayed.	2	Faults Automativcally Displayed
6.	Fault history and trending	2	Good- Last 10 faults stored with time, 12 logged drive conditions at time of fault.	0	Poor- Last three codes stored. No logging or trending available	2	Good- Data Log - 20 different parameters are logged every 160ms and recorded- However the data is lost if drive is powered down. Fault Log -- Time, trip value, and options to reset kWh or running hours.	0	Poor- Scroll to Fault Menu M6, only last 9 faults listed no data at time of fault available.

Appendix 6 – Troubleshooting and Diagnostics Comparison Detail (continued)

No.	Troubleshooting/Diagnostics Comparison	YASKAWA E7		ABB ACH400		Danfoss VLT6000		HV9000	
7.	Usability of fault display	2	Good	2	Good -Fault code is displayed with short text of fault spelled out. Data available thru serial comm	2	Good- Spells out fault name Data is also available thru serial communication.	0	Poor-Text spells out approx two words of the fault name. No operation data captured for troubleshooting.
8.	Special Features	2	Parameter range and default value are displayed for the user when changing a parameter.	2	Kypd displays factory test date	2	Nameplate Data , Installed Options and Power Component ID is Available thru display.	2	Three possible Digital Operators Available: HV Multiline-STD Type, HVGraphic(has copy function), HVMultiline-w/HOA (has HOA button)
9.	Fault Types	2	Excellent--41 faults and 18 alarms some programmable, 15 adjustment or tuning specific faults	0	28 fault codes,34 warning alarms fixed	0	28 different faults and 29 warnings	0	28 faults, 9 fixed warnings
10.	Fault resetting	2	Reset Key , cycle pwr. SAFE: Run command must be removed before fault reset.	0	Reset Key , cycle pwr DANGER: The drive will run without toggling the run command after fault reset.	2	Reset Key , cycle pwr	0	Reset Key , cycle pwr DANGER: The drive will run without toggling the run command after fault reset.
11.	Technical support	2	Excellent - Inside rear manual cover has : website, 24 hour phone, field service info, training info, and what is needed when calling data.	0	Poor- Only phone number on back cover.	0	Poor - Only Phone number and website listed inon back of manual	0	Poor - Only Phone number and website listed inon back of manual
	TOTAL SECTION SCORE	**22**	**= 100%**	**45%**	of E7	**64%**	of E7	**18%**	of E7

Legend: (0=Yaskawa Advantage), (4=Competition Advantage), (2= equal to Yaskawa), (NR = Not Rated)

T. Appendix 7 – Highlighted Danfoss VLT6000 vs. E7 Comparison

YASKAWA

Yaskawa E7 vs Danfoss VLT6000 Competitor Comparison

ABBREVIATED FEATURE AND FUNCTION COMPARISON

Features and Functions	Item	Yaskawa E7	Danfoss VLT6000 HVAC	E7 is Better
HP Range	230V	3 to 150HP @ 230V	1 to 60HP	☑
Instantaneous Trip Level	%	200%	180% for 0.5 sec.	☑
PWM Carrier Frequency	Range	See below	See below	
Minimum Frequency	Hz	0.1Hz	1Hz	☑
	NPN/PNP	NPN/PNP	PNP	☑
Digital Output Relays	Total Quantity	3	2	☑
	Resolution	9 bit	8 bit	☑
Upgradable Drive Software	Flash	Yes	N/A	☑
Accel/Decel Rate	Time	0.00 to 6000.0 sec	1.00 to 3600.0 sec	☑
Momentary Power Loss Ride-thru	Time	2 sec (model Dependent)	300 msec	☑
Braking Function	Deceleration	High Slip Braking (Faster Stopping without Options)	N/A	☑
Cooling Fan	Replaceable Without Tools (on some models)	Yes	No	☑
Harmonic Counter Measurers	Options & Range	**12 Pulse Diode Bridge** is Standard on: 30HP and Above	Filters/Reactors (Options)	☑
Serial Communications	Optional	LonWorks, DeviceNet, Profibus-DP, Modbus Plus	Lonworks, Modbus RTU, Profibus	☑

OUTPUT CARRIER FREQUENCY COMPARISON

Yaskawa E7

Voltage	HP Range (VT)	Maximum Setting without Derating the Drive
230V	3HP	**8kHz**
	7.5-10HP	**15kHz**
	15HP	**8kHz**
	20-40HP	**10kHz**
	50 to 60HP	**5kHz**
480V	0.5 to 10HP	**15kHz**
	15 to 20HP	**8kHz**
	25 to 30HP	**10kHz**
	100 to 125HP	**5kHz**
	150HP	**8kHz**
	200-250HP	**5kHz**
	350-600HP	**2kHz**

Danfoss VLT6000 Carrier Frequencies

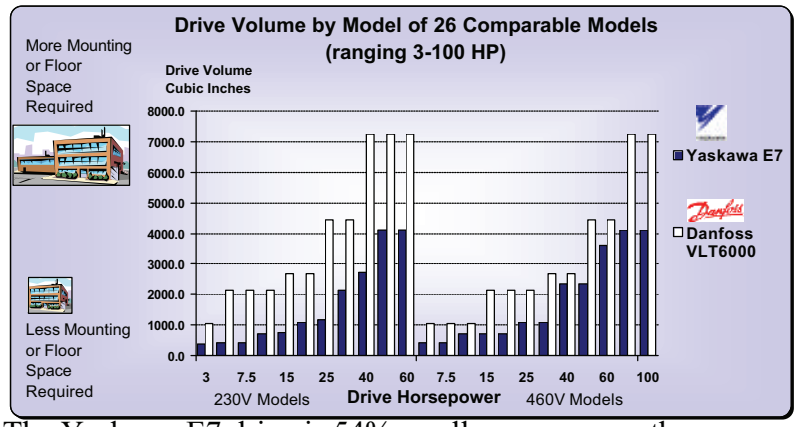
Voltage	*HP Range (VT)*	Maximum setting without Derating the Drive
230V	1 to 60HP	4.5kHz
460V	1 to 600HP	4.5kHz
575V	2 to 60HP	4.5kHz

VLT6000 carrier frequencies higher than 4.5kHz will result in automatic de-rating of the maximum continuous output current of the VLT6000 drive. The drives de-rate is linear from 4.5kHz to the maximum switching frequency of the drive. At maximum carrier frequency, the continuous output current from the drive will be limited to 60% of the rated current.

With higher carrier, motors operate cooler and quieter right out of the box with E7. No power derating is required for a quieter smoother operation.

PHYSICAL CONSTRUCTION COMPARISON

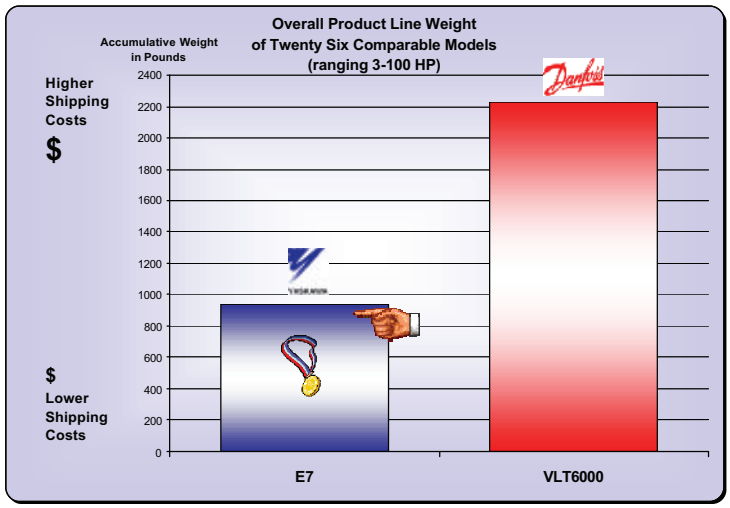
Good physical design can be measured by several important factors. Compact design can help save valuable enclosure or floor space. Installation and repair time can be minimized by well-designed enclosure features. This comparison rates the products as a complete product line not just one drive model.



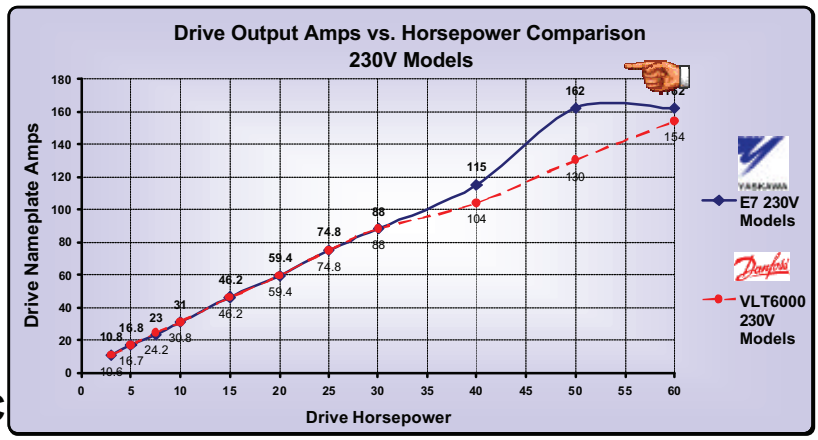
Overall: The Yaskawa E7

Takes Less Space!

The Yaskawa E7 drive is 54% smaller on average than the competition.



Weighs Less!



Delivers More Amps!

When compared to Danfoss VLT6000

WIRING AND MAINTENANCE EVALUATION

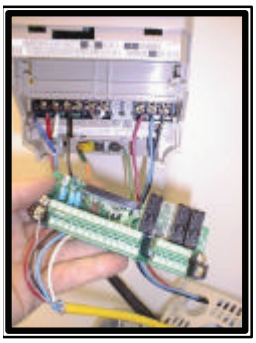
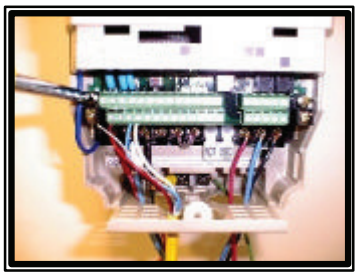
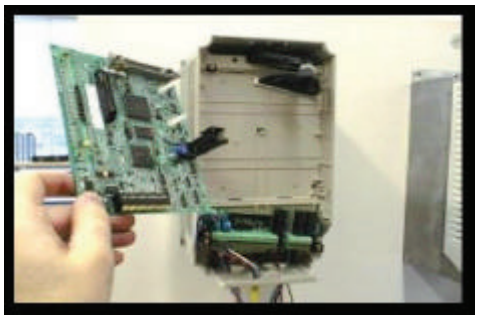
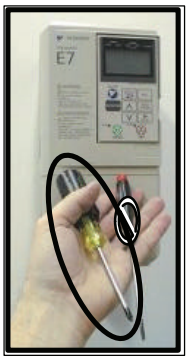
A drive that is easily wired can reduce both ownership and installation costs:

- Simple wiring and piping connections.
- Components that can be replaced without rewiring

This results in a product that is economical to install and maintain. Cost savings can be further increased by a product that does not require expensive or highly skilled personnel to maintain or service.
This comparison evaluates features related to the wiring installation of the drive.

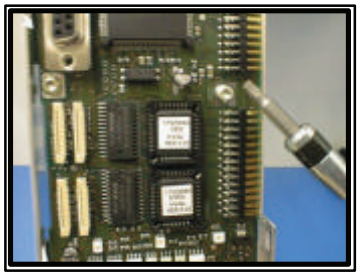
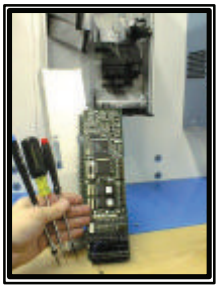
Yaskawa E7 Wiring – Comments: Wiring the E7 is easy and straightforward. Only two standard tools are required for wiring connections on this model. The unique split cover protects the control board and keeps the digital operator in place during wire termination. The easily removed pre-punched bottom conduit plate allows free hand movement. The I/O block is removed by loosening two captive screws and is easy to wire while holding in the hand. There were no unusual techniques or tools required in making wire terminations.

Simple E7 PCB Replacement – Comments: E7 main PCB replacement is performed with a single phillips tool and without removing wire terminations. The top cover can be removed with one hand. Loosen and disconnect the pluggable I/O block, two retaining screws, a single header plug and pop out the board. Installation is the opposite and is just as simple. Notice that no high voltage connections or bus bars are dangerously exposed during removal.

VLT6000 Wiring – Comments: The drive requires three tools to wire instead of two for the E7.
The control-wiring knockouts become a loose part and may get lost in the drive unless immediately discarded. The pluggable power connectors have the clamping point ¼ inch deep inside the connector. This makes it difficult to inspect for pinched wire insulation and proper electrical connection. In addition, the VLT6000 requires more effort to wall mount because it is the heaviest of the drives compared.

Difficult Danfoss VLT6000 PCB Replacement – Comments: Replacing the control PCB on the VLT6000 was more difficult than the E7, with special tools and lack of replacement instructions. The VLT6000 manual does not describe PCB removal. A separate serial communications manual explained removal as a part of option PCB mounting. However, communication manuals are not shipped unless the options are installed. PCB replacement required a T9 Torx driver and two other screwdrivers (a total of three tools). The Torx driver is a specialty tool. PCB removal required loosening 5 screws and two ribbon connectors. **Gate drive PCB replacement requires sheet metal removal and also 11 steps to reprogram the VLT6000.**

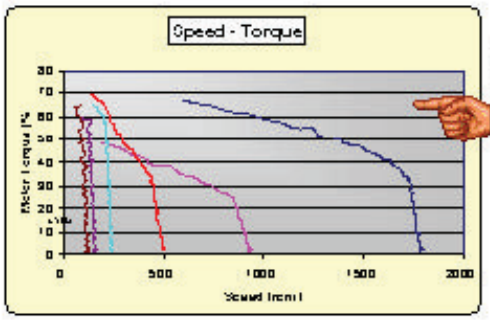
PERFORMANCE TESTS

Danfoss		Yaskawa	
Model Number	VLT6000	Model Number	E7 - 43P7
Enclosure Type	Nema 1 (IP20)	Enclosure Type	NEMA 1
Voltage Rating	460V	Voltage Rating	460V
Current Rating	8.2Amps	Current Rating	7.6A

SPEED TORQUE TEST

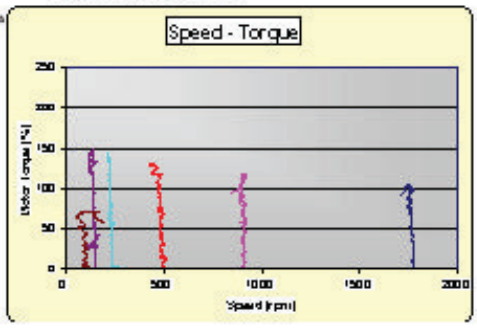
Set the drive speed reference to 60Hz and start the drive. Run the drive until the motor stalls.

VLT6000



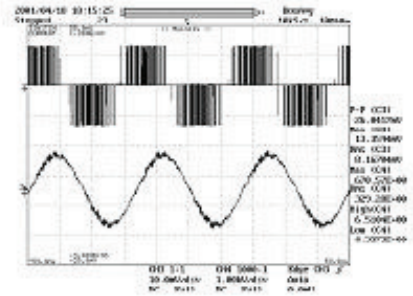
Out of the box tuning performance is poor with VLT6000

Yaskawa E7



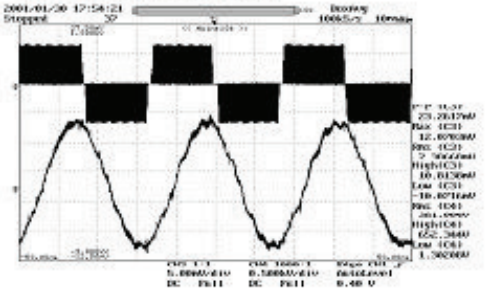
MOTOR OUTPUT HARMONIC TEST

VLT6000
30Hz Full Load
Voltage THD = 81.54%,
Current THD = 6.38%



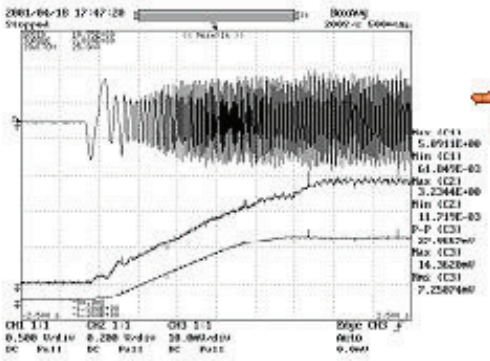
Danfoss VLT6000 motor runs hotter with higher output THD

Yaskawa E7
Output Harmonic Data – 30Hz Full Load
Voltage THD = 45.9%
Current THD = 3.76%



1 SECOND ACCEL TIME TEST-- Output Current, Motor Torque, Motor Speed

VLT6000
2 second accel time setting – Full load
(2 sec accel was achieved but
1sec accel caused OC trip)



Danfoss VLT6000 had to be set for 2 second accel to avoid tripping on OC.

Yaskawa E7
1 second accel time setting no problem– Full load